

The AMSAT[®] Journal

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CONTENTS

Silent Key Werner Haas, DJ5KQ.....1
By Karl Meinzer, DJ4ZC; Peter Guelzow, DB2OS; and Keith Baker, KB1SF

Apogee View.....3
By Robin Haighton, VE3FRH

Planning Meeting for the Phase 3D Orbit and Orbital Maneuvers.....4
By Peter Guelzow, DB2OS

Phase 3D: New Bands, Part 1.....7
By Ed Krome, K9EK

Satellite Orbital Elements.....10
By Ray Hoad, WA5QGD

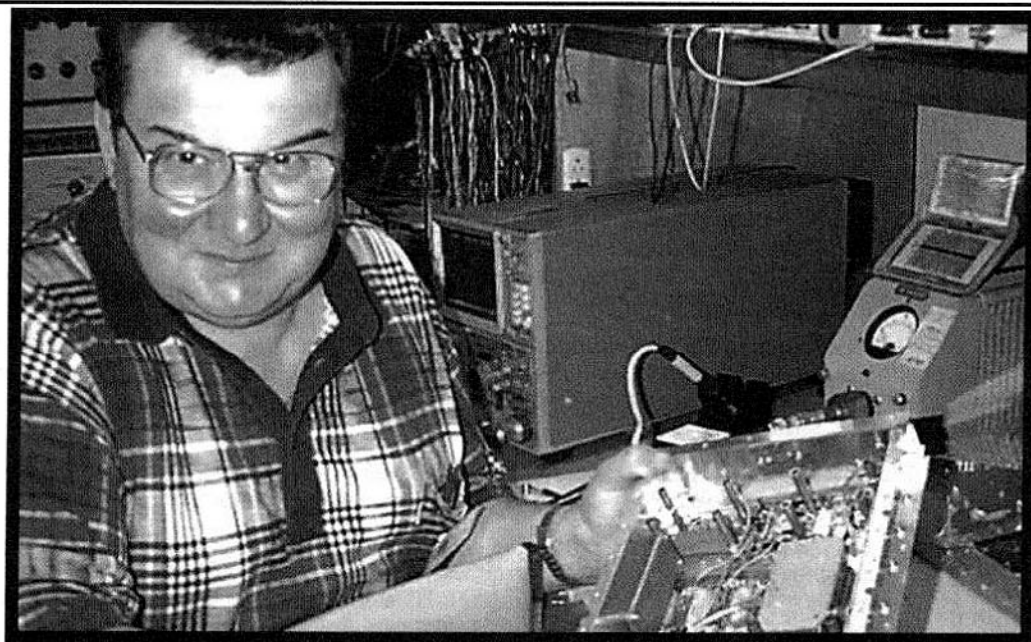
Field Ops Update: 2000 Dayton Hamvention Highlights.....11
By Barry Baines, WD4ASW

Building a Downconverter for 70 cm.....14
By Pete Carr, WW3O

Spectrum Analyzer 0....1750 MHz, Part 1.....16
By Matjav Vidmar, S53MV

AMSAT Journal Telemetry.....26

Registration Form for the 18th AMSAT Annual Meeting and Space Symposium.....31



Werner Haas, DJ5KQ performing the final check on the Phase 3D U-band power amplifier. DJ5KQ became a silent key on 13 June 2000. His leadership, fellowship, and technical abilities will be greatly missed by AMSAT. As a tribute to Werner, the callsign DP0WH has recently been assigned to Phase 3D. Similar to the practice of previous Phase 3 spacecraft, the callsign will not be regularly used in order to stress Phase 3D's multi-national character. (photo by Lou McFadin, W5DID)

Silent Key Werner Haas, DJ5KQ

Already from early age, Werner was fascinated by radio. This determined the choice of his professional career, and in 1959 he also took his license examination to become a radio amateur with heart and soul. Initially Werner started his career in the electronic retail business, but in 1965 he joined the ZEL of the University of Marburg in which he fully could bring to bear his genius for electronic developments.

But his interests and ambitions reached beyond the purely professional; in the early seventies Werner got intrigued by the possibilities offered by combining radio-technology and space-satellites. This combination of disciplines became the guiding star for the rest of his life. This found its formal expression in the foundation of AMSAT-DL; from the first hour on Werner shaped the development of AMSAT serving as Vice President.

[continued on page 4]

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Apogee View

Launch Time

At the time of writing this column, in mid July, I have just heard that the Phase 3D launch may be delayed until mid-November, due to problems with the final stage attitude control of the launch vehicle. Naturally I am disappointed at this further delay, but to quote President Keith Baker, "It is better that they found the problem here on earth, when it can be corrected, than in space after launch." The launch previous to ours has also been delayed to mid-September for the same problem. Let me say a few words about the launch campaign, this is not a simple *put it on the rocket and fire it off*, but many final checks have to be made to the satellite, systems activated and tested in order to keep the reliability high. For over the next few months Phase 3D will be required to meet all the adverse conditions that the AMSAT designers, engineers and scientists have anticipated and tested for during the manufacture and assembly of our satellite.

On take off the "G" forces and vibration will try to shake Phase 3D apart, but we have designed and tested for that. When in orbit the UV and radiation will severely test our solar cells and electronics, but again we have designed and tested for these conditions. Our thermal calculations, which have been checked and re checked will be tested to insure that thermal balance is maintained around the satellite, and the heat transfer system will be operational.

To insure that these parameters are maintained, the satellite will undergo final inspection, test and operation of each of the electronic devices during the launch campaign, have the batteries charged, and the fuel loaded into the six fuel tanks, any abnormality will be corrected prior to loading Phase 3D onto the launch vehicle. The final experiment to be installed, the laser system, will also be connected during this phase.

This involves several people visiting the launch site from both AMSAT-NA and AMSAT-DL to carry out those functions for which they have the expertise. Unfortunately with the extensive complications of Phase 3D, one person cannot do all the work. When all the work is complete, Phase 3D will be mounted on the SBS ring as the secondary payload for this launch, and while the primary payload is placed above Phase 3D and until launch, it will be necessary to monitor the satellite, and keep the batteries charged through an umbilical cord.

At launch, the cord will be removed, and the "G" forces begin. When the satellite is first in orbit, a further series of tests will take place to determine that all is well with the operation of the satellite and the satellite's own arcjet motor will be fired to start to maneuver Phase 3D into its final orbit. This will take several months to accomplish, during which time the satellite may be available for limited times dependent on the needs of the satellite controllers to test Phase 3D and to establish the correct orbit (For more details on post-launch activities see *Planning Meeting for the Phase 3D Orbit and Orbital Maneuvers* by Peter Guelzow, DB2OS on page 4 of this issue.)

Currently we have controllers in Germany, Australia, New Zealand, USA, and UK. I will not list all of the systems, sensors and circuits that have to be checked and re-checked to insure successful operation of Phase 3D, however many people are going to be working very long hours before and after a successful Phase 3D launch, for the benefit of the amateur satellite radio operators world wide. Let us, the benefactors of their efforts, offer the launch campaign team, and the satellite controllers, our strong support.

73 de Robin Haighton. VE3FRH,
Executive Vice President AMSAT-NA ■

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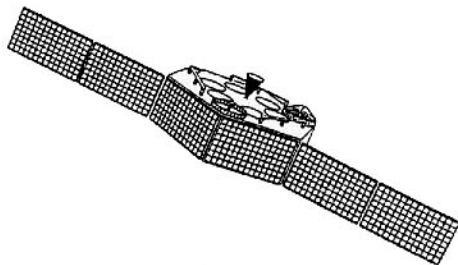
due at AMSAT-NA HQ by 15SEP00

[continued from page 1] In spite of all the administrative duties that Werner accepted for AMSAT-DL, his true heart remained with radio technology. In particular Werner was fascinated by the satellite transponders - Werner developed and built transponders for all five satellites in which AMSAT DL had a leading role. These central parts of the satellites were the major factor in the success of the AMSAT missions. Werner always was ready to pass on his enthusiasm and his technical know-how. So it comes as no surprise that Werner was not only admired, but that he also made many close friends all over the world. And just as a side effect, the flying satellite became a monument for Werner, which for decades will constitute a yardstick for technical excellence.

During his last ten years, Werner's main interest was to ensure the success of the Phase 3D satellite - for him Phase 3D was the crowning achievement of his life's work. Even when he was already marked by his sickness, Werner took it upon himself to personally travel to Orlando to perform the last acceptance tests of Phase 3D. This gave him the assurance that he had given all in his power to make Phase 3D successful.

Unfortunately Werner did not live to see the launch of Phase 3D scheduled for this autumn. AMSAT and Amateur Radio are poorer for this loss. But Werner will live on through his work and thus set an example for future generations: the world can be made a little better in the context of Amateur Radio by personal engagement and a sense of duty. We thank him for this, Werner will continue to be with us by his achievements and in our hearts.

By, Karl Meinzer, DJ4ZC, Peter Guelzow, DB2OS, and Keith Baker, KB1SF



Planning Meeting for the Phase 3D Orbit and Orbital Maneuvers

Peter Guelzow, DB2OS (db2os@amsat.org)

Editor's Note: This article originally appeared in the May-July issue of The AMSAT-DL Journal. Many thanks to Peter Guelzow, DB2OS and Frank Sperber, DL6DBN for allowing us to reprint this article and to Gerd Schrick, WB8IFM for translating this article.

Early in April Viktor Kudielka, OE1VKW, James Miller, G3RUH, Peter Guelzow, DB2OS, and Project Leader Prof. Karl Meinzer, DJ4ZC met at the headquarters of AMSAT-DL in Marburg. The purpose of the meeting was to discuss the approach and necessary orbital maneuvers after the launch of Phase 3D on board the Ariane-5. At the same time there was also a meeting with DASA (now Astrium) to discuss fueling details of the satellite with propellants for the 400 Newton motor and the arc-jet propulsion system. (Note that Astrium was created at the turn of the year by the merger of Aerospatiale Matra, DaimlerChrysler Aerospace A.G. (DASA) and Marconi Electronic Systems.)

The highly elliptical 16-hour orbit of Phase 3D is especially susceptible to irregularities caused by the gravity pull of the sun and the moon. Viktor Kudielka had already performed preliminary studies [1] on how to achieve the planned orbit with the limited resources available. Of particular concern was to achieve an orbit that would be stable for many years and not lead to the same fate as had previously befallen AO-13.

Calculations were based on a successful nominal insertion into a geostationary transfer orbit (GTO) with an apogee of 37,786 km, a perigee of 560 km and an inclination of 7°. Several other factors that depend on the exact time of the launch can only be considered after launch.

At the time of the meeting a question was received from Arianespace whether a modified GTO was acceptable to us. This GTO could lead to a maximum apogee of 39,122 km, which is 3,340 km higher than the nominal value, but it might also be 1,649 km lower than the nominal value. The perigee with 590 km would also be higher, however the inclination would be reduced to 6.5°. The idea here is obviously to fully utilize the resources of the rocket to increase

the weight of the payload and save on fuel that the satellite needs to take along to get to and maintain the final orbit for a long life-span. If it were not for the most unfavorable orbit, this modified orbit would also be of advantage to us. Subsequently we discussed in detail the risks and advantages of this approach. In principle, we could live even with the most unfavorable GTO offered, but the available propellants would be used up faster and long lasting maneuvers using the arcjet would be required to save fuel. This is not nice, but we could live with it and there is, of course, the chance for a quite favorable orbit as well.

The fully fueled AMSAT Phase 3D satellite weighs in at 650 kg (unfuelled 402.3 kg). Fuel consists of 196.7 kg MMH (monomethyl-hydrazine) and N₂O₄ (nitrogen-tetroxide) for the 400 N (Newton) rocket motor and 51 kg of ammonia (NH₃) for the arcjet. 15.7 liter of helium at a pressure of 200 bar is also carried along to pressurize the propulsion systems in orbit. The bi-propellant 400 N motor facilitates at an Isp (specific impulse) of 306 sec a delta V of 1150 m/sec and the 0.1 N arcjet with an Isp of 408 to 510 sec produces an additional delta V of approximately 450 m/sec. Using these data, Viktor Kudielka explored a number of possibilities for maneuvering Phase 3D into its final orbit. To report about these maneuvers would, however, go beyond this article. An Internet address is provided at the end of the article that contains further information and outlines the strategy used to select the orbit for Phase 3D.

Considering all advantages and disadvantages after a nominal launch we face the following situation:

1. GTO: Assumed is a launch with a resulting GTO of 6.5° inclination, a perigee of 590 km and an apogee of either 39,122 km (optimal) or 34,122 km (minimal). Three hours after separation from the last rocket stage the on-board computer automatically activates the 70 cm telemetry beacon (general beacon, GB). Because of the uncertainty of the spacecraft's attitude, omni-antennas are used. At this point in time (see Figure 1) the spacecraft will be over Asia and our command stations in Australia (VK5AGR) and New Zealand (ZL1AOX) will examine the telemetry and establish

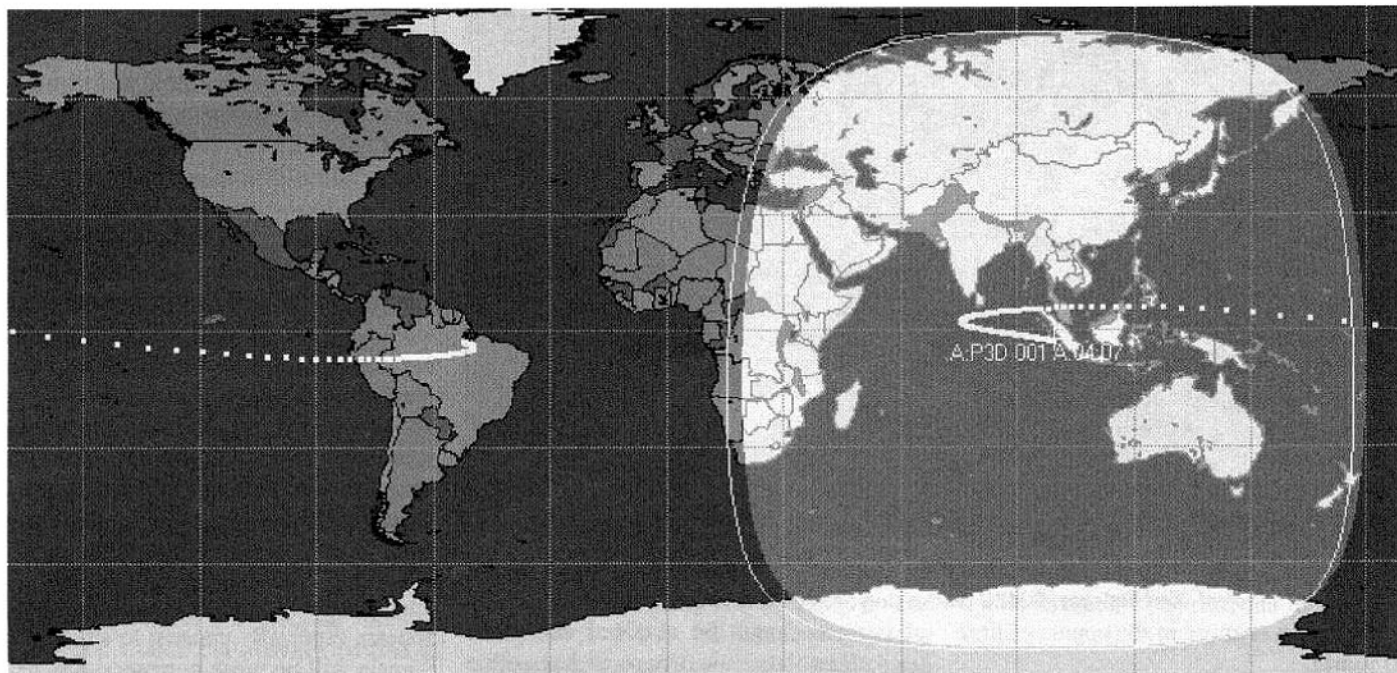


Figure 1. Shortly after launch Phase 3D will be in a 6.5° inclination with a perigee of 590 km and an apogee of either 39,122 km (optimal) or 34,122 km (minimal). At this time the telemetry beacon will be activated and Phase 3D command stations in Australia and New Zealand will obtain first contact with the satellite.

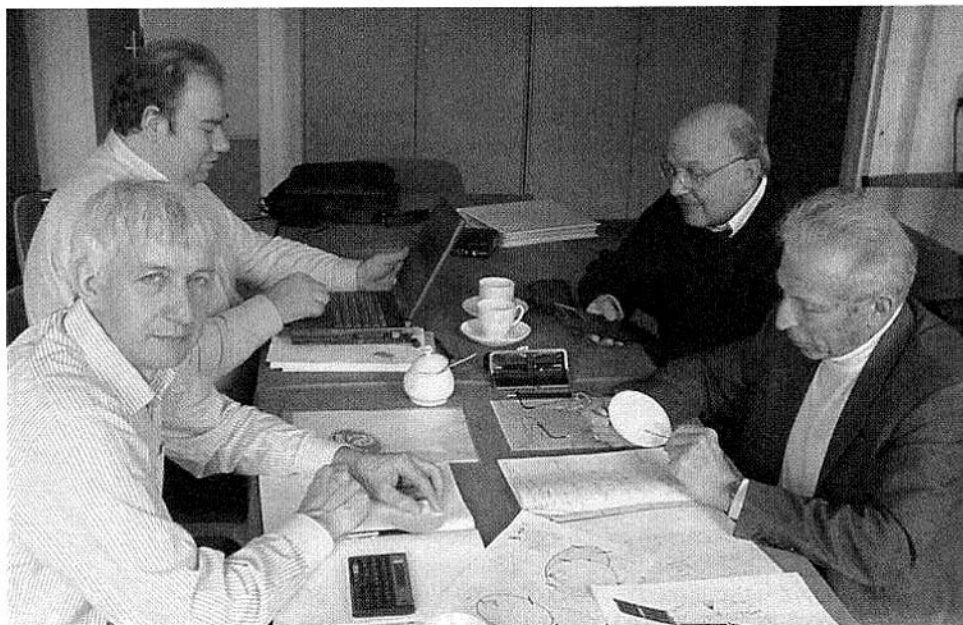
connection with the on-board computer to check out the command links. In Europe, Phase 3D will be heard only 4 to 5 hours after launch. In the days following, several important systems will be activated and checked out. The middle telemetry beacon (MB) for the IHU-2 (internal house keeping unit) is turned on at times; likewise the 9600 Baud downlink of the IHU-2 will relay to the ground camera pictures of the separation as well as data from the acceleration sensors and the microphone. Subsequently RUDAK will be turned on and software loaded to activate the two GPS receivers and perform first radiation measurements with the CEDEX (Cosmic-Ray Energy Deposition Experiment). After the position sensors and the magnetic position regulating system have been checked out and calibrated preparations for operating the arcjet can begin.

2. Arcjet Maneuvers: Depending on the obtainable Isp of the arcjet and the apogee reached by the firing of Ariane-5's second stage the apogee will be raised by the arcjet through intermittent firings over a period of 270 days to a range of 60,000 to 70,000 km. The argument of perigee will drift during this time from 178° to about 270°. The arcjet will be fired from one to two hours during perigee. The firings will be automatic, computer controlled since no command station can see the satellite during this time. In the past automatic computer control was

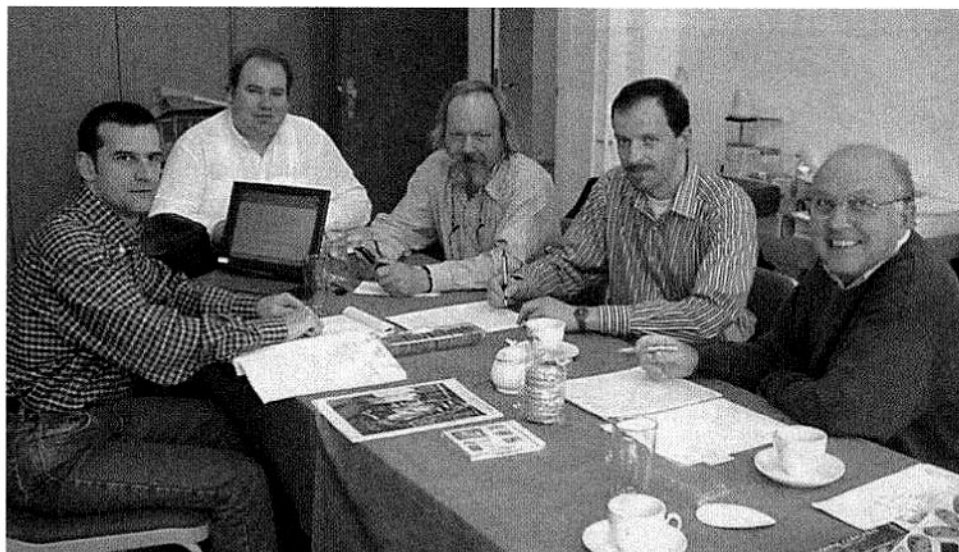
used for AO-10 and AO-13 even in cases where the satellite was in good view. During this nine-month period there are approximately four months when an unfavorable sun angle will not permit firing of the arcjet. Depending on the remaining electrical energy, however, the satellite will then for the first time be available for radio amateur use. After those 270 days there will

be another 5 to 6 weeks needed for additional maneuvers with the 400 N motor.

3. Bi-Propellant Motor Maneuver: The 400 N motor will raise the inclination to about 63°. This burn takes place at apogee and could simultaneously adjust the perigee to 4000 km. However, raising of the perigee is unnecessary since, caused by perturbations, the orbit will raise the perigee



From left to right James Miller, G3RUH; Peter Gulzow, DB2OS; Karl Meinzer, DJ4ZC; and Victor Kudielka, OE1VKW discussing plans for post-launch Phase 3D maneuvers.



From left to right are Thomas Maier, DASA; Peter Guelzow, DB2OS; Wolfgang Muller, DASA; and Prof. Karl Meinzer, DJ4ZC discussing Phase 3D propulsion plans.

to 10,000 km or more in the course of time (10 years).

4. Bi-Propellant Motor Maneuver: After the orbital parameters have been accurately determined and further calculations made, another firing of the 400 N motor takes place to *fine adjust* the inclination. This maneuver also takes place at apogee a few days after the first firing. The desired inclination is $63^\circ \pm 2^\circ$ depending on the right ascension of the ascending node (RAAN). The goal is a slow drift of the argument of perigee around 252° as determined by the selected inclination. Thus, over a period of 20 years, the argument of perigee will change from 315° to 270° to 225° . A more stable argument

of perigee cannot be obtained under our limitations of the ratio of mass of the satellite to the mass of the propellants.

5. Bi-Propellant Motor Maneuver: Finally a further firing of the 400 N motor will reduce the apogee to 47,700 km to obtain the desired 16-hour orbit.

6. Three-Axis-Stabilization: After extensive tests of the position regulating system and the momentum wheels the spin-mode of Phase 3D will be converted to three-axis-stabilization. Now the solar panels, still wrapped around the satellite, can be unfolded and full electric power to

operate several high power transmitters becomes available.

Provided everything works as planned, Phase 3D will reach a final and stable orbit in less than 12 months and not almost two years as previously assumed. As mentioned above, Phase 3D can be used during part of this time. However, signals will not compare to the expected strengths achievable with full power and 3-axis-stabilization, which permits use of the gain antennas pointing towards earth. At the initial argument of perigee of 315° stations located at the 50th parallel north will experience a visibility of 15 hours per day while stations at the southern 40th parallel still have access for 5 hours per day. This would also be true for an Argument of Perigee of 225° .

Following the sequence of firings above, the intermediate apogee of 60,000 to 75,000 km appears especially unusual to say the least. Signals will be weak corresponding to this distance; however, this intermediate situation is for a good cause. On getting from A to B, one has a choice. Using *full throttle* one arrives in the shortest period of time. However, a lot of fuel is used (air-drag increases with the 3rd power of speed) and one is in danger of an accident. Going more slowly, less fuel is used, but the trip takes longer. On the other hand one gets to the destination relaxed and safe. Of course, for Phase 3D there is no air resistance! But Viktor Kudielka demonstrated with his calculations that similar rules apply to space and a proper strategy, even with limited resources, can lead to the desired results. Aside from reaching the final stable orbit it was important for the planning that Phase 3D is in no danger should a motor prematurely fail or even should a motor fail during a maneuver. To get to our goal faster, only the removal of several modules to reduce weight would have been an option. But, who wants to make that selection? Better safe than sorry.

As shown as Figure 2, Viktor, OE1VKW, provides data sets for Phase 3D immediately following launch to the year 2013.

References

1. "Alternative Start Sequences and Orbital Evolution of Phase 3D," *Proceedings of the 15th AMSAT Annual Meeting and Space Symposium*, Toronto, 103-110 pp, Oct. 1997. This paper is available in PostScript (2.63 MB) at <http://www.oe1kib.ampr.org/~oe1vkw/toro2.ps>

2. Personal communication from Viktor Kudielka. ■

Start: 01 August 2000 23:00:00 UT

Apogee: 39122 km, Perigee 590 km;
P3D 001

1 99001U 00099Z 00214.97200000 .00000000 00000-0 00000-0 0 016

2 99001 6.5000 109.0000 7340000 176.0000 0.0000 2.04300000 09

Start: 01 August 2000 23:00:00 UT

Apogee: 34122 km, Perigee 590 km;
P3D 002

1 99002U 00099Z 00214.97200000 .00000000 00000-0 00000-0 0 017

2 99002 6.5000 109.0000 7060000 176.0000 0.0000 2.37400000 06

Data Sets for the planned 16 Hour Orbit of Phase 3D.

Date: 07 January 2002 (Orbit #600):

P3D 003

1 99003U 00099Z 02007.00000000 .00000000 00000-0 00000-0 0 034

2 99003 63.5000 327.0000 7830000 352.0000 0.0000 1.50000000 6009

Date: 01 July 2013 (Orbit #6900):

P3D 004

1 99004U 00099Z 13182.00000000 .00000000 00000-0 00000-0 0 042

2 99004 74.0000 87.0000 6000000 315.0000 0.0000 1.50000000 69006

Figure 2. Estimated post-launch Keplerian data sets for Phase 3D.

Phase 3D: New Bands, Part 1

Ed Krome, K9EK

k9ek@amsat.org

With the excitement over the impending launch of Phase 3D, many people are working hard to improve existing satellite stations and add new capabilities. The AMSAT reflector is full of discussions on higher frequencies, high speed digital, all kinds of neat things! Last year, S-band (2401 MHz) downlink got a boost from the availability of Drake 2880 downconverters, readily convertible to amateur service. I expect that S-band downlink will be a very popular band, indeed.

The lower bands are all pretty well known. Even the 1269 MHz uplink is much less exotic than it used to be with the availability of plug-in modules for popular satellite transceivers. Check out a recent edition of the ARRL Handbook for a simple, homebrew antenna/amplifier combination to finish out your 23-cm uplink package.

Several bands haven't seen much discussion. As might be suspected, these are the higher bands; uplinks on 2401/2446 MHz and 5668 MHz and downlinks on 10450 and 24050 MHz. As a long time high frequency experimenter and general AMSAT enthusiast, these bands are of great interest to me. This and subsequent articles will discuss some of the basics of higher frequency operation and discuss one man's approaches to operation on these frequencies. This is not supposed to be a construction article, though everything discussed has been built (and even works!), but rather to take some of the mystery out of things.

Where to Start

Lesson one is that the sensible place to start is the one that costs you the least time, effort and money. The fact is that UHF receiving is a LOT cheaper and easier than transmitting. And the lower the frequency, the less inexpensive and more available the gear. Currently, 23 cm is the highest band supported by off-the-shelf ham gear, and that is an uplink-only band. For 13 cm and above, equipment shifts from one-piece boxes to distributed components. A fact of physics says that the higher the frequency, the greater signal loss in a piece of feedline. To a receiver, feedline loss looks like increased noise. And low front end noise is

the most important part of a receiving system. The most practical method of reducing feedline loss is to eliminate the line. We do this by mounting preamplifiers (and sometimes even whole converters) directly at the antenna.

Since a 13cm downlink was active on AO-13, this mode has already been well documented. A good reference, also useful on all higher bands, is *Mode S: The Book* available from AMSAT.

Higher Yet

The next downlink band beyond 13 cm is 3 cm.... quite a jump in frequency, and complexity. Phase 3D has two separate antennas and amplifiers on 10450 MHz; one of them a 60 watt traveling wave tube amplifier (TWT), the other a 10 watt solid state. These should provide a booming signal to a small dish and make this frequency very popular with both techies and even *normal* people!

On 10450 MHz, it may not be enough to follow the *low frequency* (like 13cm!) techniques of antenna mounted preamp and shack mounted converter. Feedline losses may be so high that will be necessary to mount the receive converter right up close to the antenna feed. Probably the most physically satisfactory arrangement will be

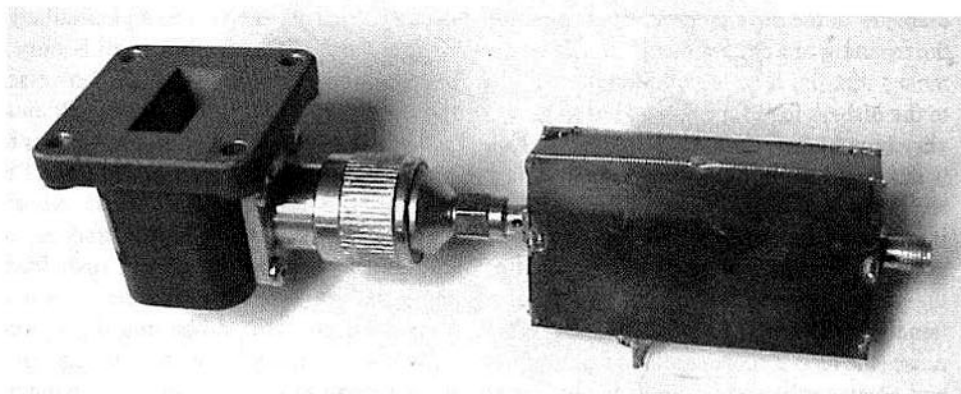
to mount the preamp right at the antenna feed, then use a short-as-possible length of high-quality (RG-213 or better) coax to get from the preamp, around the rotators to a weather-proof box containing the receive converter, mounted high on the tower. Then the lower-frequency connection to the IF receiver itself (in the shack) can be made through normal cable with minimal signal loss.

Details

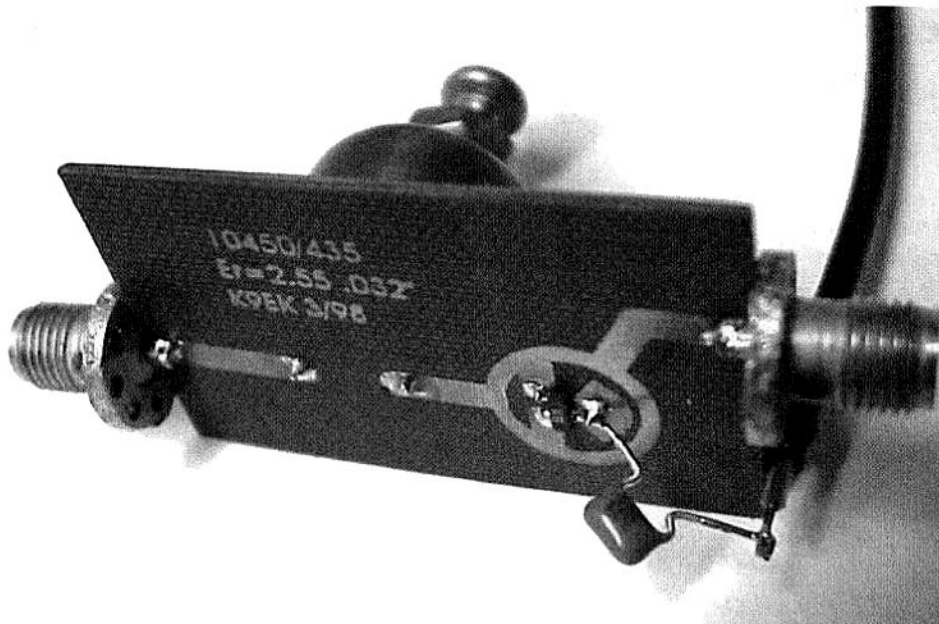
Following are discussions on the various parts common to S-band and higher satellite receive systems. The basic requirements are 1) the antenna, 2) an antenna-mounted low noise preamplifier, and, 3) the converter.

Antennas

Link margins done by Frank Sperber, DL6DBN and shown on the AMSAT-DL web site indicate anticipated antenna sizes. On 10450 MHz, a 60-cm (24" diameter) parabolic dish antenna should be adequate. While other types of antennas, such as horn and lens may find some users, the dish is probably the most readily realizable. Yagis aren't practical. Dish antennas can be homebrew or purchased; sources should be advertised as Phase 3D becomes a reality. It is possible that the small offset-feed TV



An X-band waveguide transition to be used as a linearly polarized dish feed. The attached box is a 10 GHz preamp.



A 10 GHz to 70cm mixer with a printed 6/4 mixer.

dishes may be adequate, but we really won't know until Phase 3D is up there.

A common misconception about parabolic dish antennas is that the dish has some parasitic relationship (like the undriven elements on a Yagi antenna) to the operation of the antenna. Not true; the dish itself is just a reflector that concentrates signals on a particular point called the feedpoint. We place a small antenna of known pattern characteristics (hopefully matched to the reflective characteristics of the dish) at that feedpoint and call it a dish feed. A dish feed is never characterized by *gain* but by illumination characteristics, usually an angle between the -3dB field strength points. Parabolic dishes themselves are characterized by their diameter and their *f/d* (focal length divided by diameter) ratio. The feed used must have an *illumination pattern* that is matched to the *f/d* ratio of the dish to properly utilize the area of the dish. Note that, when matching a feed to a dish, only the *f/d* ratio is significant, not the actual diameter of the dish itself. To give a feel for the meaning of *f/d* ratio, a *low f/d* such as 0.3 means that the feed is mounted quite close to the dish. A feed for a 0.3 *f/d* has to have a very broad beam to illuminate the dish that it is very close to. A *high f/d* such as 0.7, requires a narrower beamwidth feed to illuminate the dish, since the feed is mounted some greater distance in front of the dish. What is better? The *deep* dish (small *f/d*) tends to pick up less background noise (the feed is more shielded from the hot and noisy earth) and is mechanically easier to support, but it is more difficult to illuminate properly. *Shallow* (large *f/d*)

arrangements tend to have larger feeds (more directional) and are physically more difficult to support and counterbalance. Whatever you use, the feed characteristics must be matched to the dish. A significant determining factor is to use whatever you can get!

Another aspect of parabolic dish use is the diameter of the dish itself. The gain of a dish antenna is related to the diameter of the dish. This is all fine until one realizes that while higher gain means more signal strength, it also means narrower receiving beamwidth. For moonbounce service, a huge dish is fine, because the moon doesn't move very fast. But satellites are rather speedy. The larger the dish, the more difficult it will be to keep it pointed where you want it. Generally, the smallest dish that will give satisfactory signal strength is the most desirable.

Phase 3D signals will be right-hand circularly polarized. Ideally, your antenna should also be circularly polarized. The desired hand of receive antenna circularity is right hand. Since the dish itself is only a reflector, bouncing a signal off it reverses the hand. Therefore, the dish feed itself must be left hand. Practically, it is much easier to fabricate a linearly-polarized feed. The performance penalty for linear versus circular is 3 dB, a reasonable tradeoff to mechanical complexity. Linear dish feeds for 10450 MHz usually take the form of a coax connector with probe in a short piece of WR90 (.9" x .45") waveguide, frequently with a small horn on the end to accurately control the beamwidth. The feed shown is simply an X-band coax-to-waveguide

transition. Though hardly optimum, it is suitable for use in a 0.4 to 0.5 *f/d* dish.

Preamps

All receiving systems for the bands 70 cm and higher require special attention to minimizing noise figure. This normally requires an antenna-mounted RF preamplifier, though some converters are designed to be mounted directly at the antenna feed. It is probably best to purchase a built-and-tested preamp from Down East or SSB. Down East also has kits available for W5LUA-designed preamps that should do quite nicely. The problem with any preamp kit is that it may not function optimally as built. Specialized noise figure testing equipment is required to optimize performance.

Whatever preamp you use, the preferred mounting is right on the dish feed itself. However, some preamps may be so large that they are physically difficult to mount or may actually shadow a significant area of the dish. Just mount them as close as possible and use good line and connectors between the feed and the preamp. SMA connectors and UT-141 miniature copper hardline are preferred over N connectors and coax, though both will work.

Preamps are rated by noise figure and gain, both specified in dB. The preamp noise figure really sets the weak signal performance for the entire system. On 10 GHz, a satisfactory noise figure is less than 2 dB. Gain is somewhat less important, with 10 dB being about normal for a single-stage device. If you are feeding a converter mounted fairly close to the preamp, this is all that is required. If, for some reason, you want to drive a really long (and lossy) piece of coax to the converter, a higher gain preamp may be required. If your converter itself has that kind of noise figure, mount it as close to the feed as possible and dispense with the preamp.

Converters

A converter converts one frequency range to another by mixing the original frequency with a fixed local oscillator signal. In this manner, we can use a common receiver with different converters (*front ends*) to economically cover several bands. A transverter is the same animal, but it converts both receive and transmit signals. This is not a unique thing; the popular Yaesu FT-736 is basically a 10.7 MHz receiver with plug-in converters. There are no

plug-in modules for bands higher than 23 cm, so we must use separate converters. The separate converter is also more amenable to the remote mounting (in a weather-proof box on the tower, below the rotators) as previously mentioned. Converters for 10 GHz typically use intermediate frequencies of 2m or 70 cm. It is satisfactory to plug one receive converter into another. For example, a 10 GHz converter with a 70 cm output frequency could be plugged into a 70 cm in to 10m out converter, which could be plugged into an HF receiver. Works fine. In selecting and applying a converter, one thing to watch is proper frequency conversion. Remember that the satellite allocation of the microwave bands is not the same as the weak-signal portion.... so hamfest weak-signal converters may not be useable. True, most converters can be modified to move band coverage, normally by changing a local oscillator crystal, but this is generally work for those with the test equipment to make sure the converter works properly after modification. Don't guess.

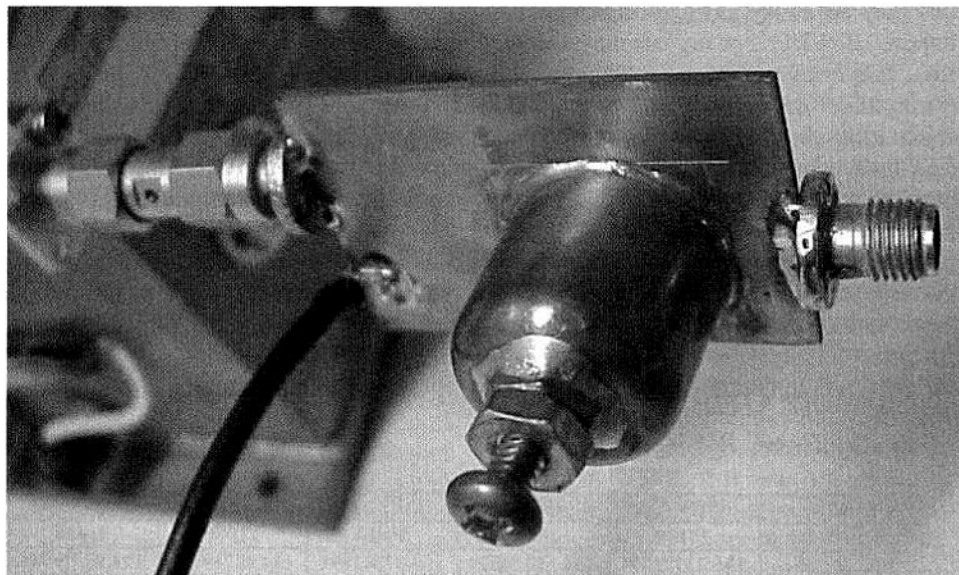
Actual Equipment

As a builder and experimenter, I tend to build some strange but simple gear. I like to see how simple I can make things. My simplest 13cm receive converter had a single transistor in the RF section. That single GaAsFET (\$5) was mounted at the feed of a 30" dish and drove a small Mini-Circuits balanced mixer (\$5), which mixed the 2401 with a 2256 MHz signal from a simple LO to send a 2m signal down a piece of RG-58 coax to the shack. Made a lot of contacts on Mode S with that simple setup.

The approach to 10 GHz is similar. The conversion system itself consists of 3 parts; the preamp, the mixer/filter and the local oscillator.

The preamp is a 2-stage W5LUA-design bought as a kit from Down East Microwave. It will be mounted directly on the dish feed horn, under an inverted Tupperware plastic container. Fancy.

The mixer itself is built on a 3/4" x 1-1/2" piece of Teflon circuit board. It has 2 parts, a filter and what is referred to as a 6/4 printed ring mixer. The filter is a 1/2" copper pipe cap soldered to the board, with 2 short wire probes sticking up into the cap. Filter tuning is through a 6-32 brass screw in the top of the cap. These filters have been detailed by Kent Britain, WA5VJB and others. They are simple, but are difficult to tune without a swept signal source. The mixer itself has 6

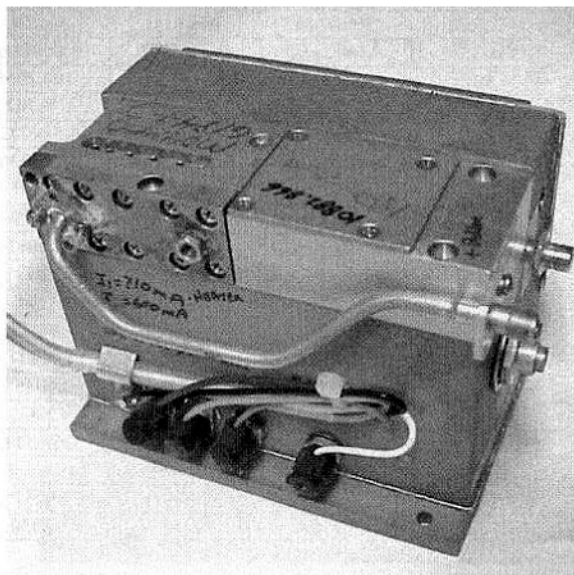


Pipe-cap filter side view of the 10 GHz to 70cm mixer.

segments, each 1/4 wavelength long (physically shortened by the dielectric constant of the Teflon circuit board), arranged end-to-end in a ring. The length of each segment is the arithmetic mean of the RF and LO frequencies. A matched dual-diode in the center of the ring is the actual non-linear part of the mixer. The Intermediate Frequency (in this case, 70 cm) is taken out through a capacitor and fed to the following 70 cm receiver. Note that there is no filter on the output of the mixer, so I get the sum, difference, image and spur frequencies of the mixing products. This converter relies on the selective properties of the following receiver to pick the right one. Since there are not a lot of interfering signals on 10 GHz, this should work just

fine. I chose a 70 cm IF because of available shack receivers. This will drive a 70 cm to 10 m converter to an HF receiver. This mixer/filter is so small, it will probably be mounted piggy-back on the preamp at the dish feed.

The Local Oscillator is the most problematic part of the entire system. There have been many published designs for crystal controlled oscillators followed by amplifier/multiplier/filter chains to provide the 10016 MHz LO (10450 - 434) signal. They tend to be complicated. I chose a simpler though less common solution. The large brick shown is a surplus Frequency West phase-locked RF oscillator module, re-crystaled and adjusted to provide the



A 10 GHz surplus local oscillator brick.

proper output frequency. The down side is that they are noisy, difficult to retune and require -19 VDC. For my use they are just fine. This brick will be mounted up on the tower, under the rotators, and feed its LO signal up to the ring mixer mounted at the dish feed behind the preamp. A possible problem with this outdoor mounting will be frequency drift over seasonal temperature swings. Most of these brick oscillators have ovenized crystals, but unless you want to keep the LO powered up all the time, you

will have to tolerate the frequency drift before stabilization. While this is considered a real problem for terrestrial and weak signal use, it might not be so bad for satellite use. We satellite users are accustomed to Doppler shift moving the frequency of our signals all over the place. This will just be one more source of frequency shift.

In the next few months, I will be talking about equipment for other bands. In the

meantime, get QRV on new bands and modes. Phase 3D should be great fun!

10GHz Equipment Sources

- Down East Microwave, 954 Rt. 519, Frenchtown, NJ 08825 USA, Telephone: 908-996-3584, www.downeastmicrowave.com
- SSB Electronic USA, 124 Cherrywood Dr., Mountaintop, PA 18707, Telephone: 570-868-5643, www.ssbusa.com ■

Satellite Orbital Elements

by Ray Hoad, WA5QGD

Satellite	AO-10	UO-14	FO-20	RS-12/13	RS-15	FO-29	AO-27	UO-11
Catalog Number	14129	20437	20480	21089	23439	24278	22825	14781
Epoch Time	195.73723774	194.68718575	194.87501691	194.92719139	194.95379946	194.78532805	194.95487094	195.89391156
Element Set	662	538	244	261	486	343	885	303
Inclination	26.8341	98.4066	99.0574	82.9223	64.8156	98.5868	98.4037	97.9841
RA of Node	321.5054	260.8379	320.471	166.6783	138.8219	99.2804	251.0224	158.5053
Eccentricity	0.6016275	0.0011484	0.0540855	0.003088	0.0167237	0.0351296	0.0008269	0.0012116
Arg of Perigee	67.7673	136.4284	357.1706	55.0221	284.6067	160.6321	179.3506	22.2246
Mean Anomaly	343.7839	223.7805	2.6371	305.3812	73.6359	200.856	180.7685	337.9503
Mean Motion	2.05869918	14.30461674	12.83274705	13.7420461	11.27537775	13.52726771	14.28170103	14.72244986
Decay Rate	-0.0000007	0.00000245	-0.00000025	0.00000082	-0.00000038	-0.00000033	0.00000021	0.000002022
Epoch Rev	12847	54651	48857	47321	22841	19275	35415	87623
Satellite	AO-16	DO-17	WO-18	LO-19	UO-22	KO-23	IO-26	KO-25
Catalog Number	20439	20440	20441	20442	21575	22077	22826	22828
Epoch Time	194.73675713	195.23049852	194.91716800	194.71621577	194.96867849	194.81852561	194.68850665	195.69864411
Element Set	355	331	360	334	68	956	828	799
Inclination	98.4447	98.4553	98.4523	98.462	98.1505	66.0846	98.4073	98.4026
RA of Node	267.4299	269.9349	269.3077	270.702	221.1166	316.6903	251.4034	252.5489
Eccentricity	0.0011777	0.0011736	0.0012416	0.0012637	0.0008253	0.0010492	0.0008801	0.0009891
Arg of Perigee	139.7958	136.9487	138.4548	138.9071	116.6047	313.5456	182.5672	160.7041
Mean Anomaly	220.4099	223.2616	221.7579	221.3068	243.599	46.469	177.5466	199.4519
Mean Motion	14.30534852	14.30722212	14.30633209	14.30771575	14.37742944	12.86345858	14.28317585	14.28719198
Decay Rate	0.00000263	0.0000034	0.0000026	0.00000328	0.00000372	-0.00000037	0.00000027	0.00000325
Epoch Rev	54654	54666	54661	54662	47162	37201	35414	32245
Satellite	TO-31	GO-32	SO-33	PO-34	SO-35	UO-36	AO-37	OO-38
Catalog Number	25396	25397	25509	25520	25636	25693	26065	26063
Epoch Time	194.91784766	194.92502707	195.90710781	194.95771040	195.19279495	195.66423052	191.88812140	194.66828364
Element Set	348	360	156	199	210	265	62	67
Inclination	98.7194	98.7189	31.4446	28.4615	96.4522	64.5653	100.216	100.2153
RA of Node	270.134	269.9101	105.2183	36.1541	33.1277	29.3484	58.2721	61.5467
Eccentricity	0.0002505	0.0002151	0.0365391	0.0007166	0.0153997	0.0046947	0.003883	0.0037884
Arg of Perigee	34.9628	52.1563	307.1351	180.2959	98.2102	293.7339	88.8741	80.2773
Mean Anomaly	325.1754	307.9819	49.6417	179.7627	263.6592	100.7773	271.6887	280.268
Mean Motion	14.2269459	14.22424319	14.24861058	15.05977293	14.41342668	14.73544461	14.34241687	14.34322361
Decay Rate	-0.00000044	-0.00000044	0.00000949	0.0000308	0.00000624	0.0000036	0.00000226	0.00000262
Epoch Rev	10431	10432	8964	9377	7283	6620	2361	2401
Satellite	WO-39	UNK3	UNK4	OCS	MIR	ISS	Phase 3D - 1	Phase 3D - 600
Catalog Number	26061	26093	26094	26062	16609	25544	99001	99003
Epoch Time	194.56510953	195.59585366	194.57247528	195.78971836	195.79876182	195.80457176	214.97200000	7.00000000
Element Set	81	77	54	194	836	829	1	3
Inclination	100.2135	100.2099	100.2102	100.225	51.6476	51.5822	6.5000	63.5000
RA of Node	61.4995	62.6746	61.4076	65.2276	124.297	3.9336	109.0000	327.0000
Eccentricity	0.0037495	0.0038175	0.0037894	0.003581	0.0013234	0.0005114	0.7340000	0.7830000
Arg of Perigee	79.6304	78.9101	81.9482	62.0328	154.3375	171.5809	176.0000	352.0000
Mean Anomaly	280.9096	281.6405	278.6211	298.5119	205.8271	33.9457	0.0000	0.0000
Mean Motion	14.34734663	14.35103681	14.34705788	14.48627613	15.68583516	15.66898539	2.04300000	1.50000000
Decay Rate	0.00000687	0.00001983	0.00000992	0.00057682	0.00048316	0.00042434	0.00000000	0.00000000
Epoch Rev	2401	2198	2131	2430	82330	9410	9	600

Note: Phase 3D Keplerian elements are provided for orbits 1 and 600. See page 6 for additional details.

Field Ops Update: 2000 Dayton Hamvention Highlights

Barry Baines, WD4ASW

What a weekend! By any measure, Dayton 2000 was a stellar success for AMSAT. Through the efforts and hard work of a number of volunteers, AMSAT enjoyed another outstanding weekend at the Dayton Hamvention. The annual event was marked by several outstanding achievements:

- AMSAT's membership incentive (an Icom IC-821H transceiver paid for by an anonymous AMSAT contributor and provided by Amateur Electronic Supply) generated exceptional interest in AMSAT membership. Over 80 new members joined AMSAT and over 200 existing members renewed at Dayton. In addition, five AMSAT members upgraded to life membership. Each individual who paid for a membership was eligible for the prize drawing that was conducted at 1200 EDT on Sunday. The winner of the Icom transceiver was Steve Block, KC8BTE of Saginaw, MI.
- Total AMSAT revenue received from memberships, books, AMSAT fashions, software, etc. was nearly double last year's total revenue.
- At the AMSAT Forum on Saturday afternoon, over 200 people created a standing room only situation in Forum Room 2 (with some attendees in the hallway). AMSAT-NA President Keith Baker, KB1SF provided an overview of current launch status of Phase 3D and described the process of getting Phase 3D from the Integration Lab in Orlando, FL to the launch facility in Kourou, French Guyana.
- As part of the AMSAT Forum, Frank Bauer, KA3HDO and Rosalie White, WA1STO presented an overview of the Space Amateur Radio Experiment (SAREX) on the International Space Station. They discussed the integral role that Amateur Radio will play on the space station as well as how schools can participate in the educational aspects of ARISS.
- A Beginner's presentation ("Introduction to Amateur Satellites") by Barry Baines, WD4ASW given during the AMSAT Forum was supplemented by AO-27 and UO-14 demonstrations by Jerry Schmitt, KK5YY over the weekend.
- Newly updated publications developed by Gould Smith, WA4SXM and Mike

Seguin, N1JEZ provided the latest information concerning Digital Satellites as well as how to use the 'Easy Sats.' AMSAT also had a new Phase 3D Frequency Chart (developed by K9EK) to accompany the laminated AMSAT Frequency Chart updated by W3XO.

- The AMSAT booth featured a number of items of interest to amateur satellite enthusiasts, including the latest version of QuikTrak.
- The AMSAT Dinner at the Amber Rose Restaurant on Friday evening was 'sold out' with excellent food and was a great opportunity to socialize with satellite enthusiasts from around the world.

As always, the Hamvention weekend of May 19-21 provided a wonderful opportunity to socialize, view the latest products (such as Kenwood's latest satellite radio currently under development), and take home some bargains. Dayton continues to be the premier hamfest in North America with throngs of people, acres of fleamarkets and commercial exhibits, a strong forum/presentation schedule, and 'unofficial' events on Friday and Saturday evenings. AMSAT traditionally maintains a strong presence at Hamvention, with a very large booth display, an outstanding forum presence, and opportunities for people to obtain the latest AMSAT materials and information. This year's Hamvention was also the first time that the ARRL held their National Convention as part of Hamvention. In addition, the recent restructuring of Amateur Radio,

coupled with great weather and an excellent economy resulted in an extremely busy weekend for vendors.

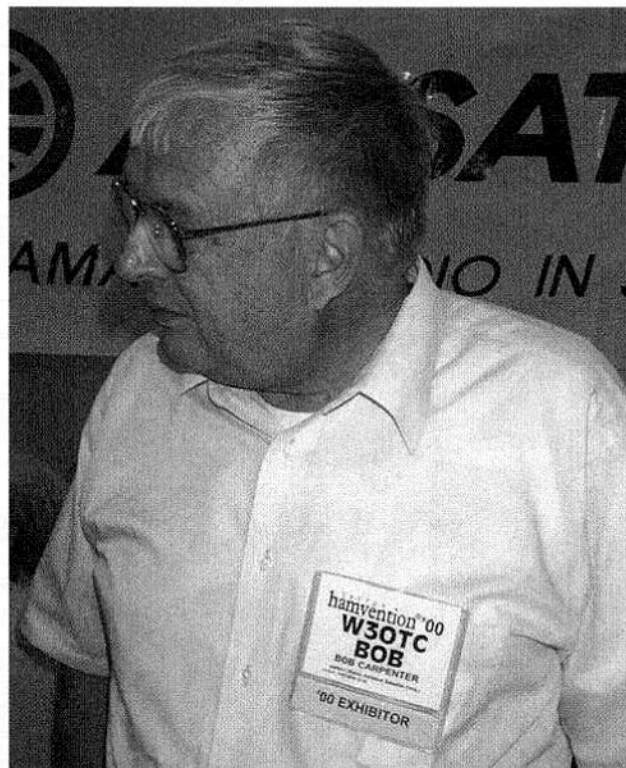
Preparations for Dayton began months in advance of the actual Hamvention weekend. As in prior years, Martha Saragovitz coordinated the myriad details necessary for getting materials to Dayton. Printing of AMSAT materials, arranging the latest in AMSAT fashions (such as utilizing the new AMSAT patch design created by Steve Thompson, K5PK that was incorporated into new golf and T-shirts), ordering stock (such as the Arrow Antennas), and shipping the boxes to Dayton are just some of the functions that Martha performed in preparation for Hamvention. Meanwhile, other folks were busy preparing presentations, updating AMSAT publications and offering new items such as QuikTrak V created by Bob McGwier, N4HY and made available by Keith Pugh, W5IU. All of this effort came together the day before Hamvention when a group of volunteers arrived in Dayton on Thursday to set up the AMSAT booth. Once again, AMSAT was at its usual site (445-448). Set



Steve Block, KC8BTE (l) of Saginaw, Michigan being presented the Icom 821-H by Keith Baker, KB1SF (r). (photo by John Shew, N4QQ)



Jerry Schmitt, KK5YY provided many demonstrations on how to work AO-27 and UO-14.



Bob Carpenter is always available at Dayton to check your membership in the database. (photo by John Shew, N4QQ)

up took most of the day with the assistance of KB1SF, VE3FRH, WA1QXR, K9EK, W5IU, WD4ASW, W3OTC, WA3GOV, WB1HBU, and others. AMSAT continues to use the booth materials built by Mike Crisler, N4IFD and which are stored in the Dayton area. Booth decoration emphasized AMSAT-NA's Membership Drive.

The commercial exhibit area opened at 0900 on Friday versus 1000 last year. As in the past, a number of volunteers were available to man the booth throughout the weekend. Bob Carpenter, W3OTC had brought the AMSAT office computer to Dayton, allowing Office Manager Martha Saragovitz and Bob Carpenter, W3OTC to handle membership and other administrative matters. AMSAT was once again the only provider of NOVA-32 at the Hamvention, so there continued to be strong interest in the product. In fact, AMSAT sold out of the 100 copies of the CD-ROM that were available at the booth. Keith Pugh, W5IU, Howard Ziserman, WA3GOV, and others were kept very busy demonstrating NOVA on one computer while a second computer demonstrated QuikTrak V which was available for the

first time at Dayton. Keith brought his computer from Ft. Worth to provide demo support. QuikTrak V is a DOS satellite tracking program created by N4HY that is fully Y2K compatible and can be used on a variety of PC machines (such as a 286 or older machines). W5IU developed the documentation for QuikTrak V and prepared the diskettes for distribution at Dayton. AMSAT also had on hand the Kansas City Tracker which continues to be a popular item as all ten units on hand were sold out as well.

Other products available from AMSAT this year at Dayton included:

- AMSAT sold out the 36 Arrow Antennas with duplexers that were available at the booth. The latest version of the Arrow Antenna was offered which features a 'split boom' for easier storage.
- A new AMSAT patch design created by Steve Thompson, K5PK was featured on new golf shirts, T-shirts, and available as a patch. Steve's colorful design was incorporated into an outline of Phase 3-D with the words "AMSAT. Ham Radio for the 21st Century." These shirts were very popular.
- AMSAT's "Hams in Space" T-shirts were available once again this year.
- Updated Frequency Chart developed by Bill Tynan, W3XO. The new chart includes the latest available information on the various satellites launched in past 12 months. Also available was a separate sheet documenting the corresponding uplink/downlink frequencies for Phase 3-D developed by Ed Krome, K9EK. Information was also made available on amateur frequencies for the International Space Station supplied by Frank Bauer, KA3HDO.
- "Working the Easy Sats" originally written by Gary Rogers, WA4YMZ and updated by Mike Seguin, N1JEZ.
- Gould Smith, WA4SXM, updated "The Digital Satellite Guide."
- A 'Help Wanted' request was posted on AMSAT-BB on April 24 and a number of members stepped forward to volunteer some time to man the booth during the Hamvention itself. Thanks to the people who volunteered, we were able to assign an individual to each of the six workstations for all day Friday and Saturday

and most of Sunday. We also had several people 'show up' at Dayton and volunteer to work various shifts. As a result, there were plenty of volunteers to assist the multitude of attendees who wanted to establish or renew a membership, get an overview of "NOVA for Windows", pickup the latest AMSAT publications, obtain an Arrow Antenna, or acquire a new AMSAT T-shirt or golf shirt. Over 30 volunteers were assigned to various workstations at the booth during the course of the weekend.

Hamvention is not only known for the extensive flea market and commercial areas, but also for the opportunity to socialize with folks from around the world. The annual AMSAT dinner was held at the Amber Rose Restaurant in old North Dayton on Friday evening, May 19. Organized by Ed Collins, N8NUY, about 80 AMSAT enthusiasts enjoyed a buffet spread that was well prepared and moderately priced. The dining room was nearly filled to capacity with about 30 more attendees than last year. The group consensus was that AMSAT should have next year's gathering at the same location. Among the attendees were Jim Haynie, W5JBP, President of ARRL and Ken Oelke, VE6AFO, President of Radio Amateurs of Canada.

The AMSAT Forum on Saturday afternoon was perhaps one of the best series of presentations given in several years. Moderated by AMSAT Executive Vice President Robin Haighton, VE3FRH, the Forum featured three outstanding programs. With an overflow crowd attending the 1215-1430 Saturday session, Barry Baines, WD4ASW led off with a 40 minute overview "Introduction to Amateur Satellites" that was aimed at newcomers as well as providing ideas to experienced users on how they might provide information to newcomers back home. As part of the presentation, attendees also received a copy of "The Amateur Satellite Resource Guide" which provides an excellent overview of sources of information pertaining to amateur satellites.

One of the messages conveyed during Barry's presentation was the ease of using the FM satellites. He introduced Jerry Schmitt, KK5YY to the audience and announced that Jerry would do AO-27 and UO-14 demonstrations on Saturday and Sunday. In fact, a demo was conducted outside Hara Arena during the AMSAT

Forum. Jerry was very successful doing his demos with good size crowds on hand both days to watch and learn how to work Amateur Radio's FM satellites. AMSAT was fortunate to benefit from Jerry's participation. At the last minute, Jerry's attendance at Hamvention was questionable due to wildfires in New Mexico. The fires outside Los Alamos that forced the evacuation of homes and forced closure of the National Laboratory threatened Jerry's attendance. Thankfully, Jerry's home was spared and he was able to participate at Hamvention.

"Phase 3D Spacecraft Status and Launch Prospects" generated a lot of audience interest as AMSAT President Keith Baker, KB1SF outlined the status of Ariane launch schedules and described how the satellite was moved from Orlando to French Guyana.

Frank Bauer, KA3HDO arrived at Hamvention on Saturday morning to discuss the status of the Space Amateur Radio Experiment (SAREX). Frank is AMSAT's VP-Human Space Flight, and he provided an overview of the progress being made to install Amateur Radio equipment on the International Space Station. He provided a review of the efforts by amateurs in the US, UK, Japan, Russia, Italy, and Germany to develop the equipment to be placed on ISS as well as the high degree of cooperation between the various organizations. Rosalie White, WA1STO, of the ARRL Educational Department outlined how schools can qualify for SAREX contacts with ISS once Amateur Radio communications are established.

Once again, AMSAT made a significant impact on the Dayton Hamvention through the quality and variety of forum presentations, a very active and professional booth display, and the opportunity to socialize and exchange ideas. Many thanks to the dedicated, hard-working volunteers who helped make our efforts such a success by volunteering to construct and man our exhibits, answer the many questions that were asked about the amateur satellite program, solicit memberships, demonstrate the FM satellites, and encourage support for AMSAT through donations received for our AMSAT materials. As always, Dayton Hamvention was both physically demanding and a fun filled weekend coupled with a great sense of teamwork and cooperation that resulted in another success for AMSAT. Thanks!

Dayton Volunteers

Many thanks to the following members who volunteered a portion of their time at Dayton to help make AMSAT one of the best looking and most informative exhibits at the Hamvention:

- Barry Baines, WD4ASW, Jacksonville, FL
- Keith Baker, KB1SF, Xenia, OH
- Bob Carpenter, W3OTC, Rockville, MD
- Ken Chaffee, WA1QXR, Ashaway, RI
- Tom Clark, W3IWI, Clarksville, MD
- Ed Collins, N8NUY, Dayton, OH
- Eric Cottrell, WB1HBU, Lynn, MA
- Steve Coy, KB8UHY, Fairborn, OH
- Steve Diggs, W4EPI, Lilburn, GA
- Jerry Ervine, KC5YRE, Hidalgo, TX
- Dave Filmer, WB9QPG, West Lafayette, IN
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Building a Downconverter for 70cm

Pete Carr WW3O, ww3o@cs.com

Several years ago I was asked to dispose of some radio equipment for the deceased relative of a friend. One of the units was a Heathkit short wave set with analog tuning and excellent sensitivity in the 10-meter band. I purchased it for the shack and used it for years as a ten-meter monitor.

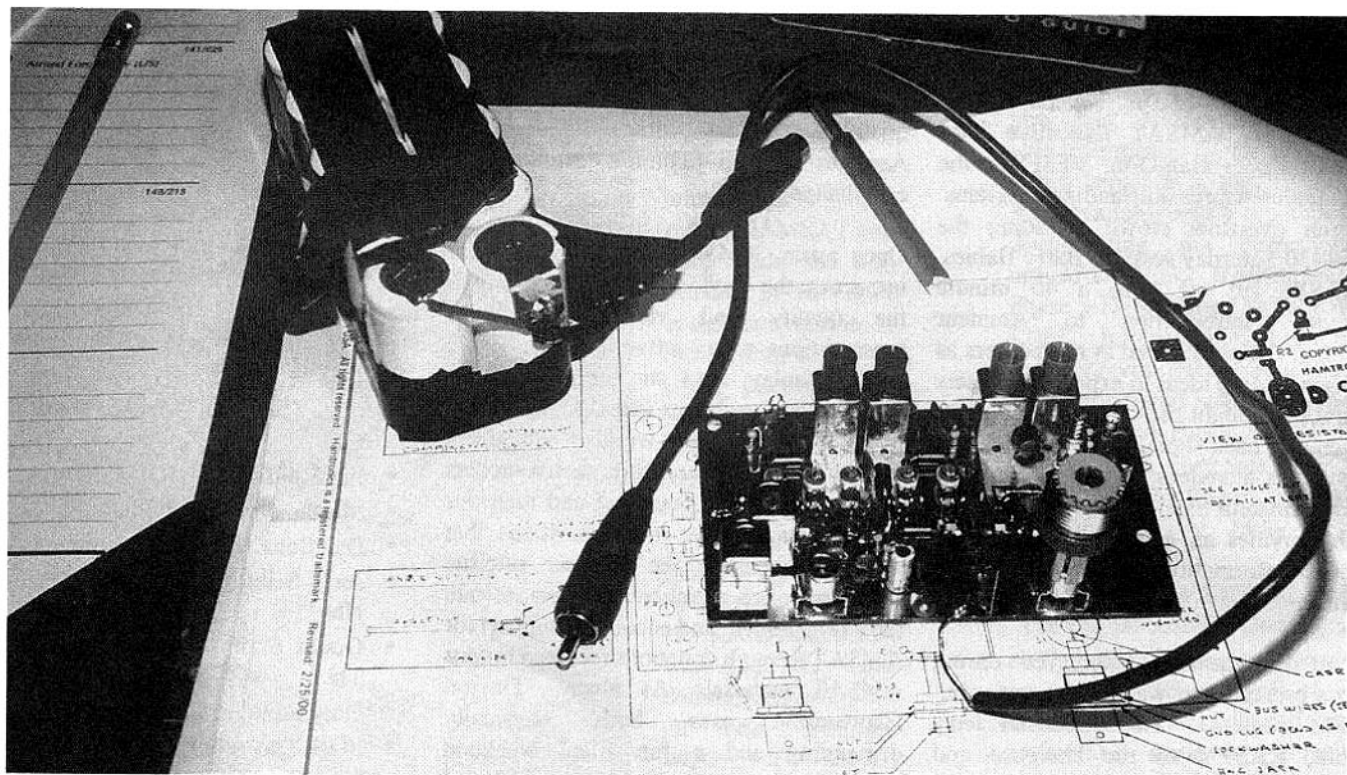
The new Phase 3D satellite and its agile frequency plan caused me to rethink the receiving capabilities of the shack. If I used the shortwave receiver as an I.F. strip and built converters for the various downlinks, it would be possible to have a shack nearly as agile as the satellite. I'd built Hamtronics kits for a 2-meter repeater and found them to be easy to tune. The 2-meter converter was also an easy project and had been in use for several months. Now it came time to get going on 70 cm. I called Hamtronics and chose a kit with a conversion bandpass for satellites. I also chose the kit without a case since I wanted to integrate the powering system for both the 2 meter and 70 cm converters.

There is an unwritten rule among VHF/UHF circuit builders that one must achieve the proper mental state. First, check biorhythms for a definite optimistic upswing, horoscope for the stars blessing and the family for a period of peace and quiet. Only after these criteria are met, would the competent builder think of gathering tools and an anti-static mat to begin work.

It is apparent that as operating frequency goes up, parts size goes down! The parts also get smaller the older I get! Included in the parts bag were 10 or so Surface Mount Technology (SMT) caps and resistors. I had very little experience with SMT. The logical next step would be to wimp-out (real men don't need no stinkin' instructions) and read the instructions. While the building sequence was not anywhere near as detailed as the old Heathkit manuals, it covered areas such as the SMT parts installation in good detail. With the help of a magnifying glass and very tiny tweezers the SMT parts were correctly installed.

The next hurdle was to make the coils that are part of the tuned coupling of the tripler circuits. I tried winding these coils using the #20 size wire supplied with the kit. The coil form is a 1/8th-inch drill bit. I tried several coils and found that the stiffness of the wire caused the coil diameter to spring open. I finally replaced the material with soft copper wire and the trouble went away. The rest of the parts were very easy to install.

There are six slug-tuned coils with square holes in the slugs. Hamtronics very strongly recommends that you purchase a special tuning tool that works with these slugs. I wanted to carve a toothpick into a tool but relented and ordered the factory tool along with the kit. This tool has a handle and is easy to use. Older Hamtronics kits came with an L-shaped tool that resembled an Allen wrench. The new one is a good buy. The tuning tool does cause some amplitude changes in signal when fully inserted into the slug. I tried tuning with the tool just barely into the hole. This caused a small piece to break off the top of the slug. If you



The 70 cm downconverter is wired with RCA phono jacks at input and output terminals. A 1250 MA 12 volt NiCAD battery is used to eliminate power supply hum. At 25 MA draw, the converter will take weeks to run down the battery. The slugs in the tunable coils require a special tuning tool. It is available from Hamtronics and is shown just above the circuit board. The connector above the battery is an UHF female to RCA adaptor used with cables to the test equipment.

tune the slug in this manner, be careful not to put side pressure on the tool to prevent breakage. Missing a piece of slug material did not seem to hurt the tuning of the coil.

I finished installing the parts and cleaned the bottom of the circuit board. Next was a close inspection to look for solder bridges and bad joints. Since I found no trouble I proceeded to the tune-up stage of construction.

Power draw for a working kit was listed as 25 mA. I used a 7 ampere-hour 12-volt battery and jumpers to connect up the circuit with the multi-meter in series. The draw before any tuning was 29 mA. So far, so good. Next, I connected a RCA to SO-213 adapter-connector to the RCA chassis connectors on the board. These accepted cables with PL-259 connectors going to a Cushman test set and an IFR Spectrum Analyzer. I set the Cushman frequency to 437.00 MHz and the IFR center frequency to 28.00 MHz. The first step of the tune-up was to set 4 slug tuned coils using a multimeter at TP-1 and TP-2. These test points tuned up just as advertised. Next, I injected a strong UHF signal into the converter and identified a corresponding spike in the 28.00 MHz baseline of the analyzer. I followed the tuning sequence of the instructions to adjust each stage and increase the spike amplitude. As an alternate tuning method, the instructions call for using a receiver with an S-meter but do not indicate where to tune the receiver. In rough tune condition the converter makes very little signal and it would be hard to locate without some guidance. Finally, I adjusted the netting capacitor to center the crystal on the correct frequency.

Power for the converter is furnished by a set of C-size Ni-Cd rechargeable batteries. The battery will run for weeks between charges and provides absolutely ripple-free power for the circuit. I used audio cable with RCA phono plugs to connect both converters to the battery.

The circuit board is housed in a plastic Radio Shack enclosure with ½ inch stand-offs. A light emitting diode and 1200 ohm series resistor are connected across the 12 volt line to nag me to disconnect power when going QRT.

With everything wired and working it's time to have some fun. I use a satellite-tracking program at www.heavens-above.com. It does all the Keplerian updates, is very easy to use and furnishes downlink frequencies



The Heathkit HR-1680 receiver has analog tuning. When used with the downconverter it makes downlink tuning very smooth. A separate speaker is required since none is installed in the RX.

for each satellite pass. There is a 2-meter/70 cm 5-element beam on the roof of the QTH that is used for local repeater operation. I connected the converter to this antenna and adjusted the short wave receiver for the 10-meter frequency of the 70 cm general beacon. At the appointed time, as predicted by the tracking program, I heard the buzz of digital data from the satellite telemetry. Signal strength was surprisingly good considering that the antenna was not tuned for that part of the band and was pointed parallel with the ground. The downlink signal lasted for several minutes after the

S-meter reading faded to noise level indicating very acceptable sensitivity.

The converter is also available for a 2-meter output. I also have a Yaesu FT-290, a very good rig, and had toyed with the idea of using it as an I.F. for this project. However, because the Yaesu has step tuning I felt that the shortwave rig would be easier to tune. If you have a different choice of I.F. rig this may be something to consider.

It is now time to play with the new toy, hone skills and wait patiently for the launch of Phase 3D. Lets hope the wait is a short one.



The two meter to ten meter downconverter has been used with the JRC receiver for quite a while. It has a Delta-tune switch that removes step tuning and is easier to use. A cheat-sheet of frequencies makes the whole adventure of satellite reception more fun.

Spectrum Analyzer 0...1750MHz

Part 1

Matjav Vidmar, S53MV

Spectrum-Analyzer Design

Wideband (panoramic) receivers and RF spectrum analyzers are usually designed as multiple-conversion receivers with the first IF above the maximum input-signal frequency. Amateur designs are mainly limited by the performance of the VCO used for the first frequency conversion. The 2-4GHz VCO presented in [1] and [2] allows the design of a simple spectrum analyzer covering the frequency range 0...1750MHz in a single span.

The resulting spectrum-analyzer block diagram, shown in Figure 1, was already briefly described in [1] and [2], although only the microwave VCOs were described in detail. In this article the remaining building blocks of the above mentioned spectrum analyzer will be described in detail, as well as the overall assembly and tuning of the completed instrument.

As already mentioned in [1] and [2], the described spectrum analyzer is a triple-conversion receiver with the corresponding IFs around 2.1GHz, 70MHz

and 10MHz. Since both the first LO and the second LO are VCOs, the first IF may be made variable. This may be useful to shift some spurious responses of the first mixer in some difficult measurements.

The described spectrum analyzer is designed to use a standard XY oscilloscope display. Additional control signals are provided to drive different displays as well as frame memories, storage normalizers, marker generators and/or trigger frequency counters. The outputs of both VCOs are also made available to drive a tracking generator or a frequency counter. Some of these additional circuits will be described in future articles.

Input Attenuator

The input attenuator is a simple yet important part of a spectrum analyzer. The main function of the input attenuator is reducing the signal level to avoid overdriving the first mixer. The input attenuator should therefore only include very linear components like resistors and mechanical switches.

The basic attenuator circuit is a simple "PI" or "T" resistor network. The resistor values are selected both for the desired attenuation value and input/output impedance matching. Since a "PI" or "T" network contains three independent resistors, all three quantities can be adjusted independently within certain limits: attenuation, input impedance and output impedance.

Generally speaking, attenuators can be built for any frequency provided that the resistors (and switches) are sufficiently small with respect to the wavelength and/or are designed as parts of transmission lines with carefully controlled characteristic impedances. Professional attenuators, both fixed and adjustable, are available for frequencies up to 18GHz and beyond, depending mainly on the coaxial connectors.

On the other hand, it is much more difficult to build good microwave attenuators from standard electronic components. Resistors with wire leads are only useful up to about 500MHz. SMD resistors are much better due to their smaller size and can be used up to at

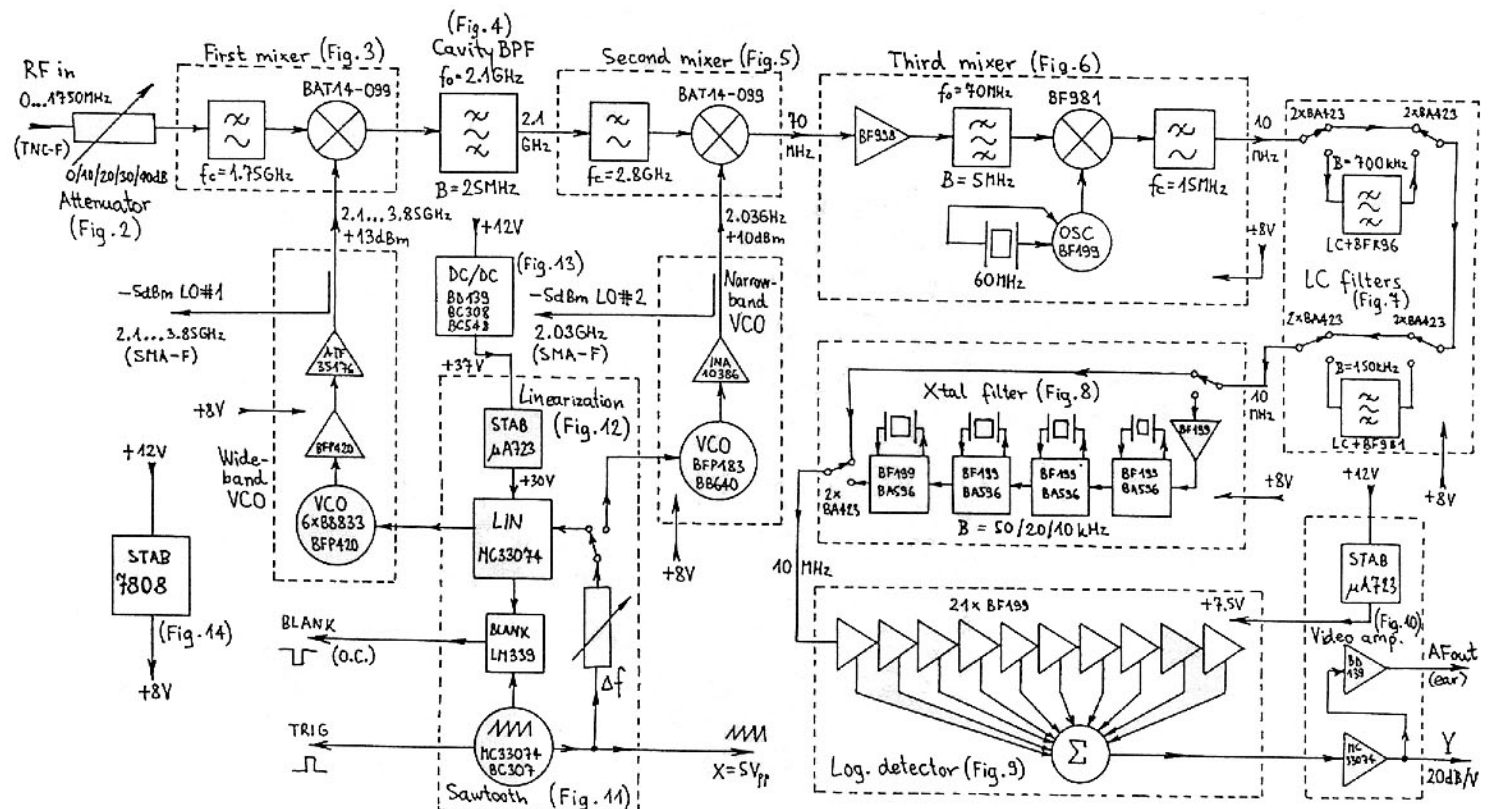


Figure 1. Spectrum analyzer block diagram.

least 5GHz. Finding suitable mechanical switches for microwave frequencies is even more difficult.

The circuit diagram of the attenuator, shown in Figure 2, therefore cannot tell much about the microwave performance of the circuit. The attenuator includes four identical "PI" networks and four DPDT switches. This design allows a nominal attenuation of 0dB to -40dB in 10dB steps.

Standard SMD resistors of the size 0805 or smaller are certainly good enough for a 2GHz spectrum analyzer. It is much more difficult to find suitable DPDT switches with low parasitics. In the prototypes standard miniature DPDT toggle switches were used. The resulting frequency response was compensated with 1pF SMD capacitors soldered across the 68ohm resistors. Finally, the toggle switches were installed between two small printed-circuit boards to keep their impedance closer to 50ohms (to be described later in this article).

A careful construction together with some compensation capacitors allows keeping the frequency response of the attenuator within +/-1dB for frequencies up to 1GHz and within +/-2dB for frequencies up to 2GHz from the nominal attenuation value. Since the maximum power dissipation of SMD resistors is 1/8W, the maximum input power to the described attenuator is about 250mW (+24dBm). At the maximum attenuation value of -40dB this means -16dBm at the first mixer input.

Of course additional (external) high-power attenuators or couplers are required for transmitter measurements. The input attenuator of a spectrum analyzer is only intended for fine adjustments of the input signal level and/or finding the source of some signals: real signals or unwanted mixing products in the spectrum analyzer?

Finally, the described attenuator does not include any protection against DC voltages that may be present in some RF circuits!

First Mixer

The dynamic range of any receiver depends mainly on the performance of the first mixer. The low end of the dynamic range is defined by the mixer noise figure (insertion loss) while the high end of the dynamic range is defined by the mixer distortion (intermodulation). Furthermore, the first

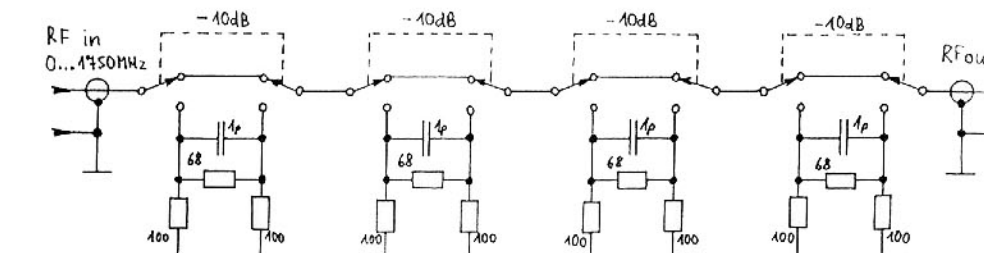


Figure 2. Attenuator

mixer of a spectrum analyzer may be easily destroyed by high RF levels, DC voltages and even static discharges on the input connector.

The first mixer of a spectrum analyzer should therefore provide both the best possible dynamic range and at the same time allow quick and inexpensive repair in the case of damage. The latter requirement makes commercially-available, doubly-balanced mixers with Schottky quads and ferrite balancing transformers impractical.

The described spectrum analyzer therefore uses an inexpensive double Schottky diode BAT14-099 in the first mixer. The balun for the local oscillator is built from UT-085 semirigid cable, as shown in Figure 3. A completely symmetrical construction allows a balancing of at least 30dB without any tuning and more than 45dB by adding small

drops of solder in the circuit. Of course the symmetry of commercially-built mixers can not be improved since the latter are built in hermetically-sealed packages.

A good mixer symmetry is required for many reasons. A balanced mixer prevents the oscillator noise from getting directly in the first IF. Further, some unwanted mixing products are suppressed in a balanced mixer. In the case of a spectrum analyzer it is especially important to suppress second-order distortion products, so that the spectrum analyzer can be used to accurately measure the suppression of the second harmonic in radio transmitters.

The first mixer module includes a microstrip lowpass filter with the cutoff frequency of about 1.75GHz. The latter should suppress unwanted responses of the spectrum analyzer

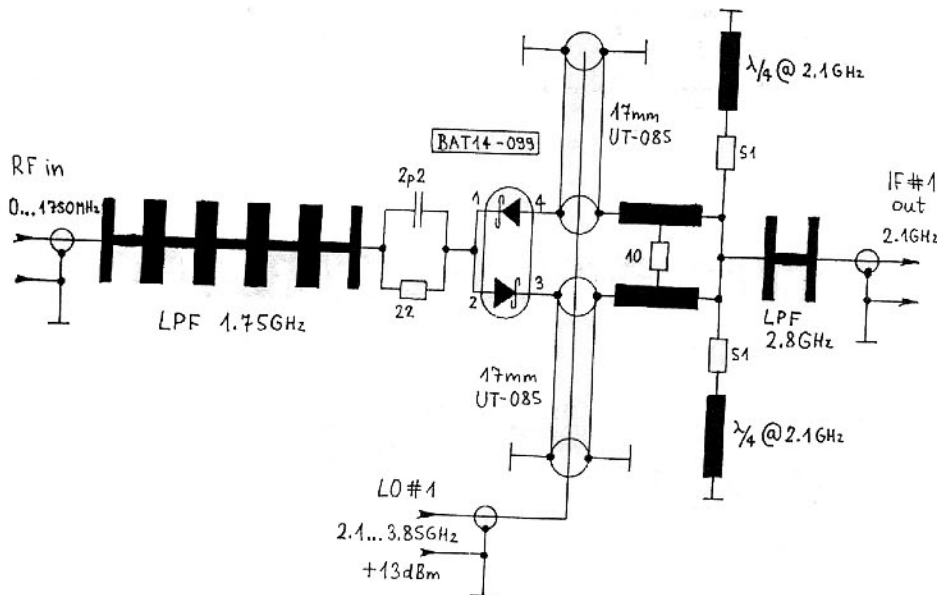


Figure 3. First mixer.

Cavity Bandpass Filter

In all wideband receivers, the first mixer should be followed by the best possible bandpass filter. In HF receivers covering 0...30MHz, a 15kHz wide crystal filter is usually used in the first IF around 45MHz or 70MHz. Considering the first IF of the described spectrum analyzer is at 2.1GHz, a cavity bandpass filter is the only technology that provides both high selectivity and low insertion loss.

Microwave cavities are electrically simple to describe, but usually require lots of precision mechanical work and special tools for manufacturing. Several efforts were spent in finding a reproducible cavity-filter design, made from standard materials using only simple mechanical tools.

The described bandpass filter is built inside a piece of standard aluminum tube with the external dimensions of 40mm x 20mm and 2mm wall thickness. Such rectangular aluminum tubing can be found throughout Europe and North America. Of course, its internal dimensions of 16mm x 36mm are the most important parameter while building a cavity filter.

The construction of the cavity bandpass filter is shown in Figure 4. The filter includes five quarter-wavelength resonators made from 8mm diameter aluminum rod. All five resonators are oriented in the same direction ("comb" filter) to decrease the coupling between adjacent resonators. In this way the overall dimensions of the filter are smaller than in the case of an "interdigital" arrangement of the resonators.

The input and output couplings are made by two small rod antennas, supported by the corresponding SMA connectors. The coupling is adjusted by the length (around 27mm) of the two antennas made of thin copper tube (UT-085 shield). The coupling between resonators is defined by the 25mm distance between resonator centers and sets the filter bandwidth to about 25MHz. Five M3 x 20mm tuning screws are used to bring all five resonators to the desired operating frequency. The tuning screws are inserted from the opposite narrow side of the cavity and secured with a counternut after tuning.

The cross-section of the cavity is small enough that the electromagnetic field exhibits a very fast exponential decay at both ends of the rectangular aluminum tube. Covers are

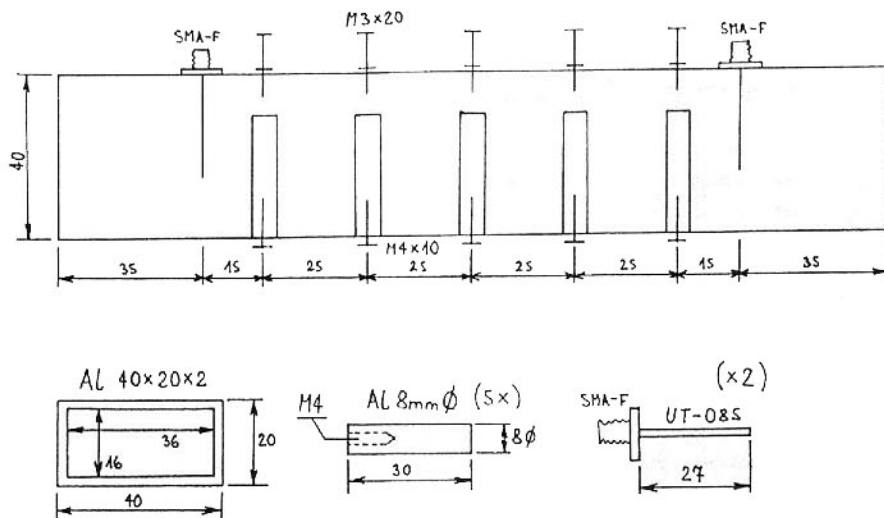


Figure 4. Cavity BPF

in the microwave frequency range. Its insertion loss amounts to about 45dB at the first IF around 2.1GHz and becomes even higher at higher frequencies. The lowpass is followed by a RC network to slightly compensate the slow decay of the sensitivity at frequencies above 1GHz.

The mixer diode BAT14-099 is followed by several components to provide impedance

matching and suppression of unwanted resonances. For example, the open end of the UT-085 balun is also used as a coupling capacitor. The two 51ohm resistors and corresponding quarter-wavelength lines provide a termination for the image frequency and other unwanted mixing products, reflected by the 2.8GHz lowpass and the following cavity bandpass filter.

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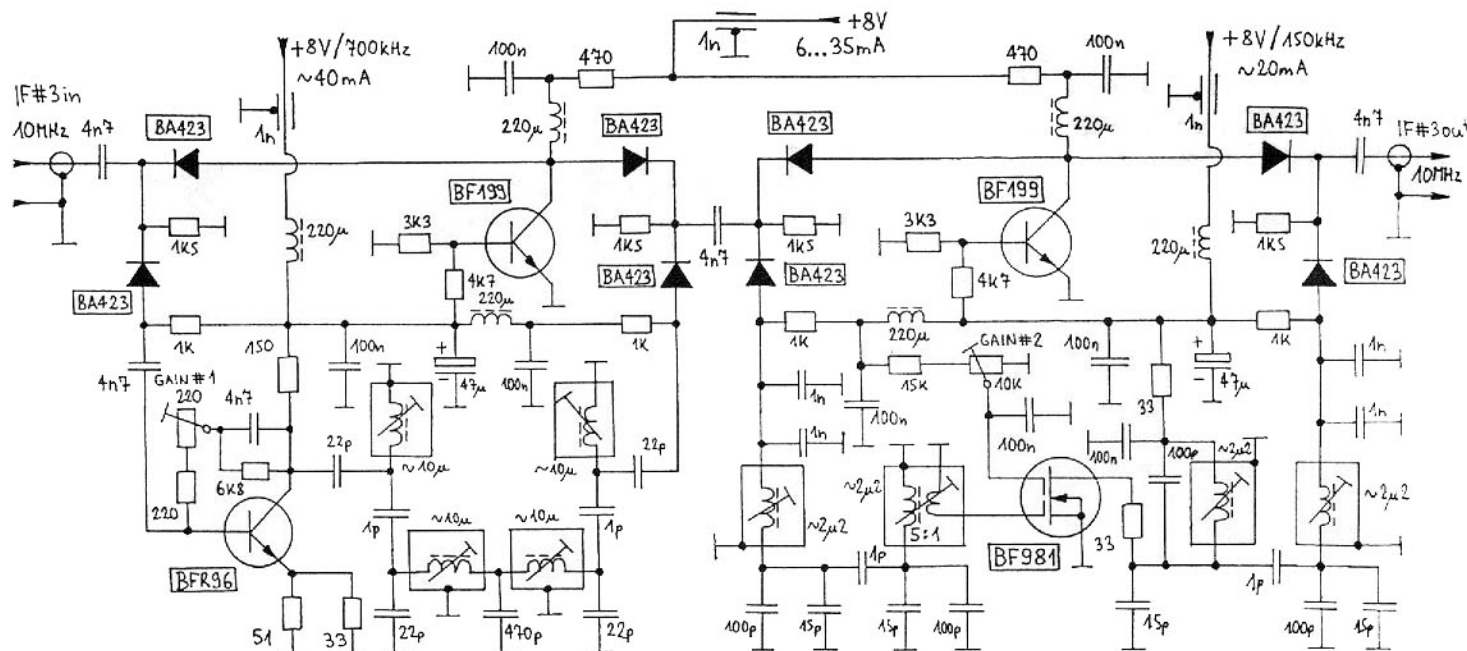


Figure 7. LC filters.

lowpass filter cuts off above 2.8GHz to suppress the spurious cavity responses above 4GHz. The output lowpass cuts off above about 800MHz to suppress unwanted mixing products and feedthrough of the LO signal.

Third Mixer

The first IF of the spectrum analyzer around 2.1GHz is far too high for the different IF filters and logarithmic detector. A more

suitable choice for the final IF is 10MHz. The latter can be conveniently reached from 2.1GHz in two downconversion steps. Due to the relatively low frequencies and low signal levels, the requirements for the third mixer are not particularly severe. An additional requirement is the maximum bandwidth $B=4\text{MHz}$ that requires a carefully designed bandpass filter at 70MHz and wideband impedance matching at the final IF of 10MHz.

The circuit diagram of the third mixer and related components is shown in Figure 6. The circuit includes a low-noise amplifier at 70MHz, followed by a LC bandpass filter for 70MHz and a dual-gate MOSFET mixer. The 70MHz low-noise amplifier (BF998) is the only true amplifier stage in the whole receiving chain of the spectrum analyzer. The only purpose of this stage is to compensate for the conversion loss in the mixers. Any gain increase or additional amplifier stages would just impair the dynamic range of the spectrum analyzer.

The LC bandpass filter at 70MHz has two functions. First, the image response of the third mixer at 50MHz has to be suppressed. Second, the widest IF bandwidth of the spectrum analyzer is defined mainly by the 70MHz bandpass filter. The bandwidth of the 70MHz LC bandpass filter itself is around 5MHz, limiting the overall bandwidth of the

complete receiving chain to about 4MHz. The 70MHz LC filter is built with adjustable coils (about 500nH) wound on shielded supports for IF transformers. The input and output are terminated with 1.5kohm resistors.

The third mixer is built with a dual-gate MOSFET BF981. The input 70MHz signal is fed to the first gate while the 60MHz LO is applied to the second gate. The mixer is followed by a lowpass impedance-matching network. The latter should both remove the 60MHz LO signal and other unwanted mixing products as well as provide a wideband transformation of the MOSFET high output impedance down to 50ohms.

The design of a suitable lowpass/matching network is complicated, since the required bandwidth is comparable to the center frequency 10MHz. Impedance matching is therefore performed in several steps with lowpass LC networks. The circuit shown in Figure 6 allows reasonable impedance matching in the frequency band 6...15MHz and a high suppression of the 60MHz LO at the same time. The circuit is built with fixed inductors of the size and shape of 1/4W or 1/2W resistors.

The third LO includes an overtone crystal for 60MHz and a BF199 transistor. The 1.5uH inductor in the emitter of the BF199 forces the crystal to oscillate on the third overtone. The

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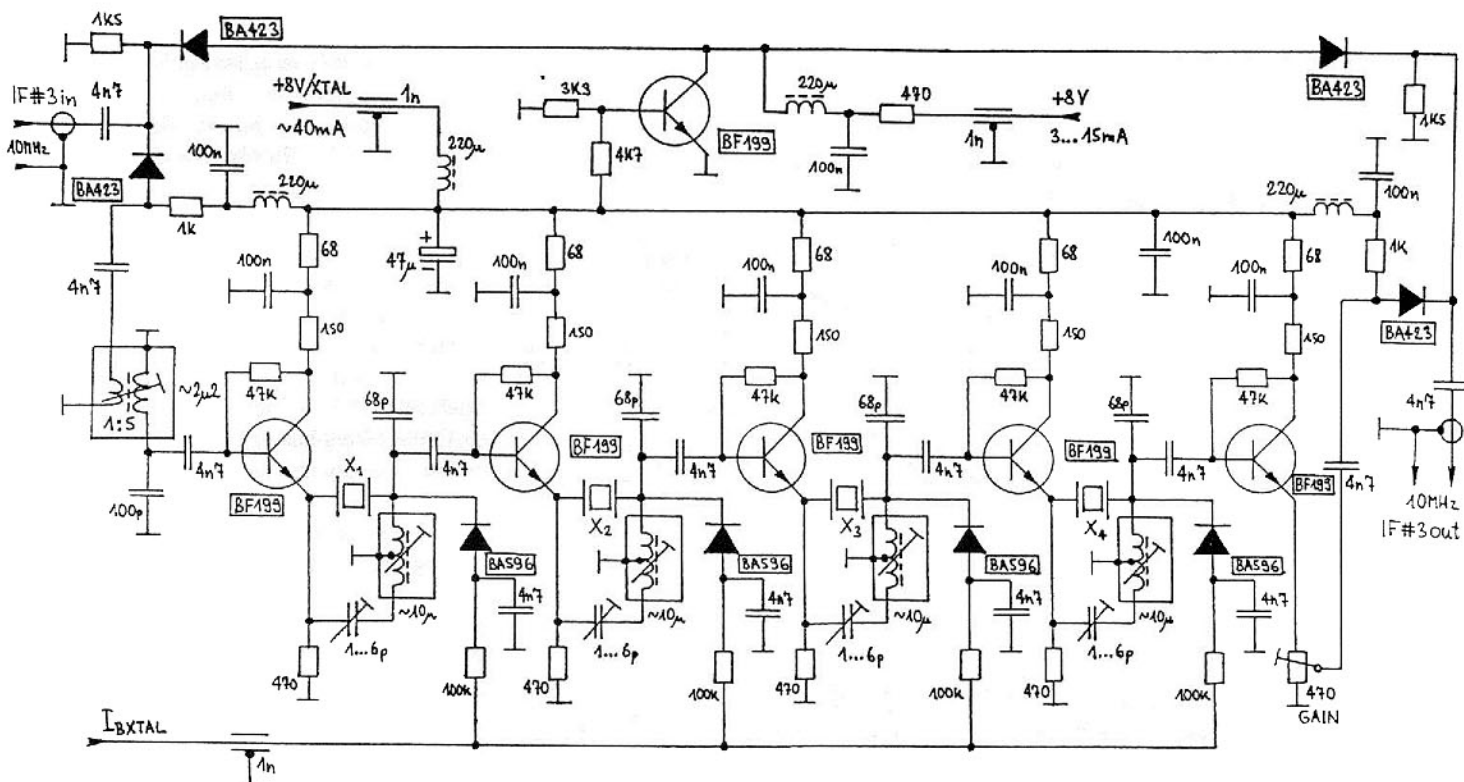


Figure 8. Crystal filter.

crystal is also used at the same time as a filter for the output signal fed to the mixer. The 1uH inductor in series with the crystal further reduces the amount of harmonics fed to the mixer. Finally, unwanted mixing products can be further suppressed by carefully setting the MOSFET bias with the trimmer "LINEARITY". The trimmer "GAIN" is set for the lowest practical gain of the BF998 that does not impair the noise figure of the whole spectrum analyzer.

LC Filters

The output of the third mixer can be fed directly to the input of the logarithmic detector, setting the IF bandwidth to about 4MHz. If a narrower IF bandwidth is desired, additional bandpass filters are required between the third mixer and the logarithmic detector. LC filters can be used for bandwidths above 100kHz, while crystal filters are required for even narrower bandwidths.

A spectrum analyzer should include several different IF filters, to be included as required in the IF chain. Filter switching can hardly be performed by standard mechanical switches only, since a crosstalk better than -100dB is required between the input and output of a filter. A better solution is electronic filter switching with PIN diodes. Each filter should

also include an amplifier to compensate for the insertion loss of the filter. In this way the measured signal strength will remain the same while switching among different IF filters.

Professional spectrum analyzers usually allow the selection of the IF bandwidth in steps of 1/3/10 etc. On the other hand, practical requirements show that just a few different bandwidths are required above 100kHz. Many different bandwidths are only required below 100kHz, where the IF bandwidth also defines the sweep time and limits the display update frequency.

The described spectrum analyzer includes two different LC filters with the bandwidths set to 700kHz and 150kHz. In addition, the crystal filter bandwidth can be adjusted in smaller steps to 50kHz, 20kHz or 10kHz. Finally, with no additional filters an IF bandwidth of 4MHz is obtained, providing a total selection of six possible IF bandwidths.

The two additional LC filters are shown in Figure 7. Each filter includes a switching network with four diodes BA423. The filter is inserted in the IF chain by simply applying the corresponding +8V supply. At the same time the BF199 transistor cuts the direct signal path and further improves the crosstalk

attenuation between the input and output of the filter.

The 700kHz wide LC filter includes four adjustable coils (about 10uH), wound on shielded supports for IF transformers. The BFR96 amplifier compensates the insertion loss of this filter. Of course the exact amount of gain depends on the loss in the coils and can be adjusted with the 220ohm trimmer.

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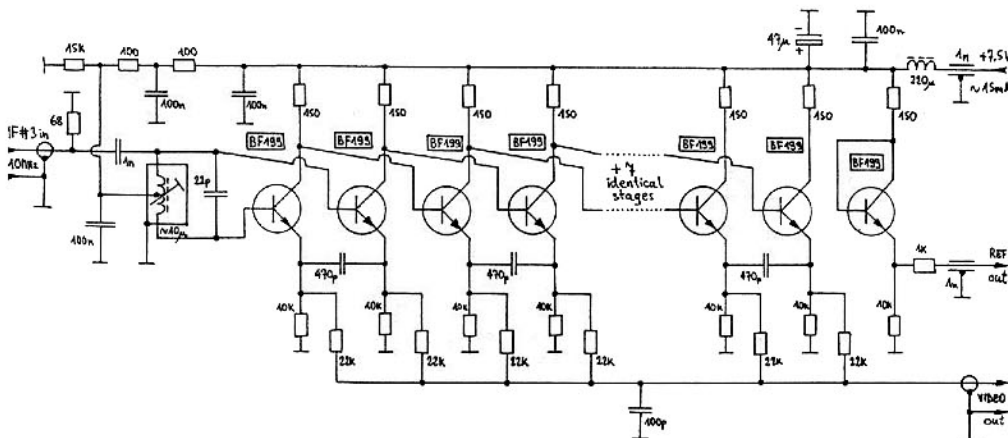


Figure 9. Logarithmic detector.

The 150kHz wide LC filter includes two separate filters, each including two tuned circuits. The required inductances are in the range of 2.2uH. All four coils are wound on slightly larger shielded supports for IF transformers to achieve an unloaded Q of about 100. The insertion loss of both narrow LC filters is compensated by the BF981 amplifier. The gain of the latter is adjusted by the bias voltage (10kohm trimmer) on the second gate.

The LC filter module requires three different supply voltages. The +8V supply should be present at all times to bypass the filters while

the latter are turned off. The +8V/700kHz supply inserts the 700kHz wide filter while the +8V/150kHz supply inserts the 150kHz wide filter. Both the input and output of the module should remain matched to an impedance of 50ohms at all times.

Crystal Filter

Spectrum analyzers require somewhat different IF filters than those installed in communication receivers. Communication receivers usually require filters with a flat passband, to avoid modulation distortion, and a very steep increase of the insertion loss

immediately outside the useful passband, to reject adjacent channels. Such filters are not suitable for spectrum analyzers, since their time response is rather slow (ringing!) compared to the filter bandwidth.

A slow filter response and/or ringing is especially harmful at small bandwidths, where the time response of the filter defines the sweep time and display update period. Commercial crystal and ceramic filters are therefore almost useless in spectrum analyzers. A suitable crystal filter or set of different filters has to be specially built for a spectrum analyzer.

A spectrum-analyzer IF filter should have a "triangular" frequency response with a sharp peak and smoothly and symmetrically increasing attenuation outside the passband. In practice this requires undercritically-coupled resonators or better a series connection of several single-resonator filters and buffer amplifiers, to avoid any interaction among the resonators.

The crystal filter shown in Figure 8 includes a series connection of four independent, single resonator filters. BF199 emitter followers are used to avoid unwanted coupling among the crystals. Each individual filter includes a single crystal in a balanced network. The capacitive trimmer is used to compensate the capacitance of the crystal. The 10uH center-tap coil resonates with the 68pF capacitor and compensates the remaining parasitic capacitances of the circuit.

The bandwidth of a single-crystal filter depends mainly on the source and load impedances. The source impedance is kept low by the previous emitter follower. The load impedance is adjustable, since a PIN diode BA596 is connected in parallel with the input of the following emitter follower. The filter bandwidth is therefore adjustable with the DC current IBXTAL fed to the four BA596 PIN diodes.

The crystal filter module includes a switch with four diodes BA423 to insert the filter in the IF chain. The supply voltage +8V should be present at all times to bypass the crystal filter while the latter is turned off. The supply voltage +8V/XTAL inserts the crystal filter. The insertion loss of the latter is mainly compensated by the emitter followers. Some additional gain is provided by the 1:5 step-up transformer at the input, followed by the first

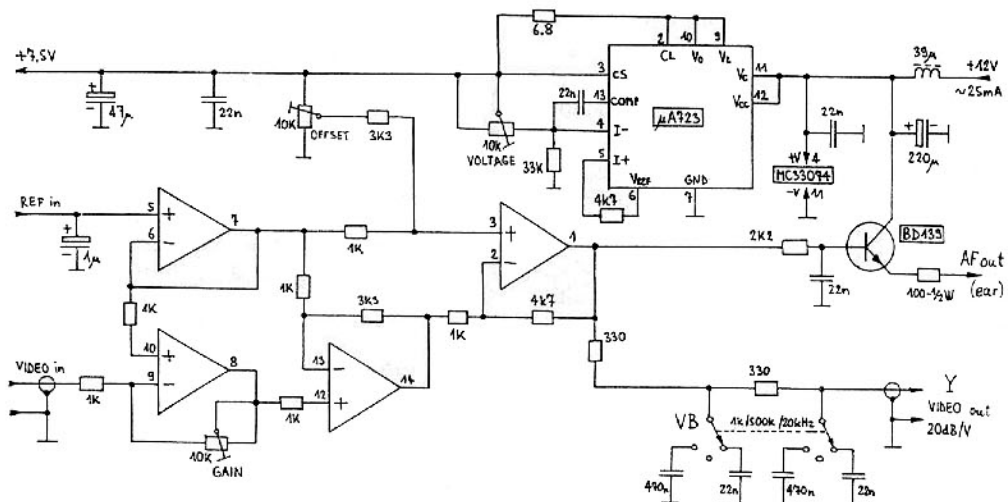


Figure 10. Video amplifier.

Logarithmic Detector and Video Amplifier

Some inexpensive spectrum analyzers (e.g. Hameg) and many amateur designs in fact use the S-meter output of popular FM-demodulator chips as a logarithmic detector. This is a very poor technical solution, since the S-meter output of most FM-demodulator chips is very inaccurate and has wide deviations from the ideal logarithmic curve. Further, the dynamic range of most single-chip logarithmic detectors hardly exceeds 70dB. Chips with a wider dynamic range require interstage bandpass filters to limit the wideband noise.

Figure 11. Sawtooth generator.

The main difference between the FM chips and the discrete circuit in Figure 9 is the use of 470pF emitter-coupling capacitors. The latter cannot be built inside a monolithic integrated circuit. The emitter-coupling capacitors allow a simple setting of the bias point and center frequency of the logarithmic detector.

Since the described logarithmic detector does not amplify DC or very low frequencies, "1/f" noise can be avoided resulting in an up to 20dB increase of the dynamic range. The

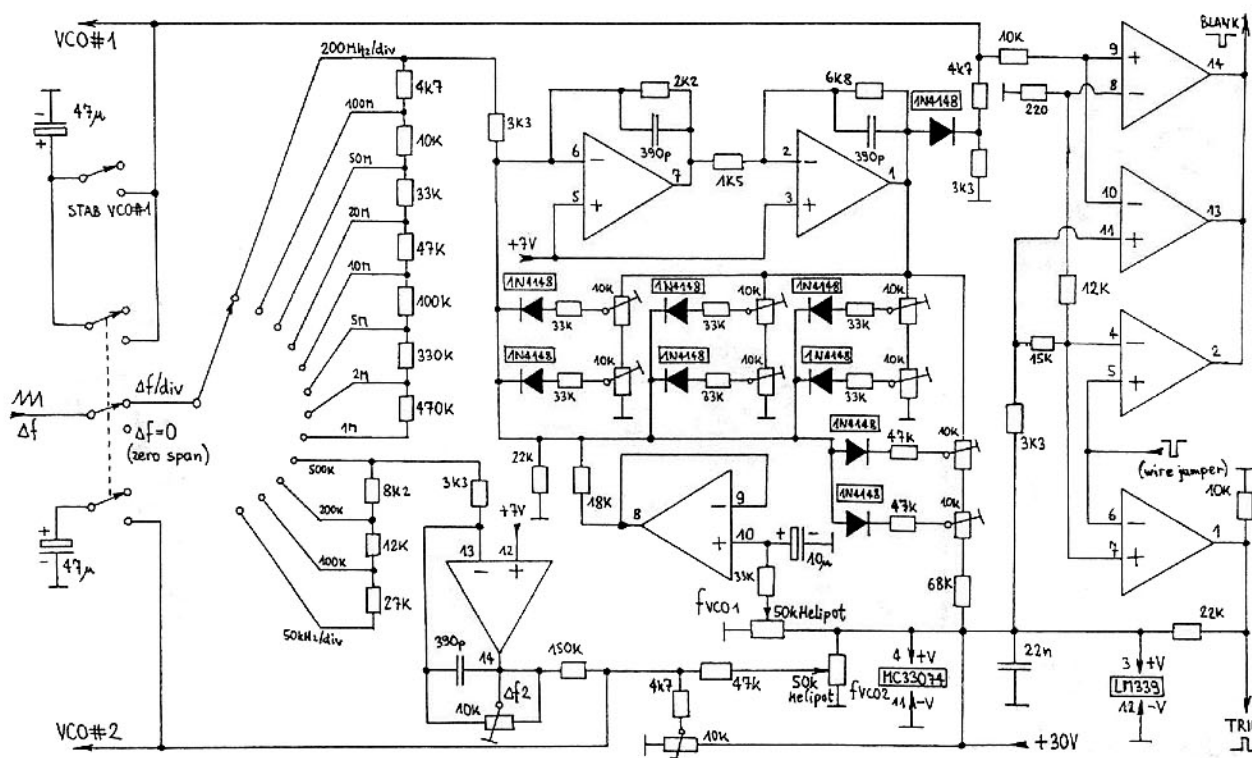


Figure 12. Linearization.

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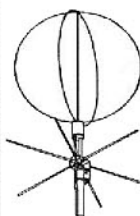
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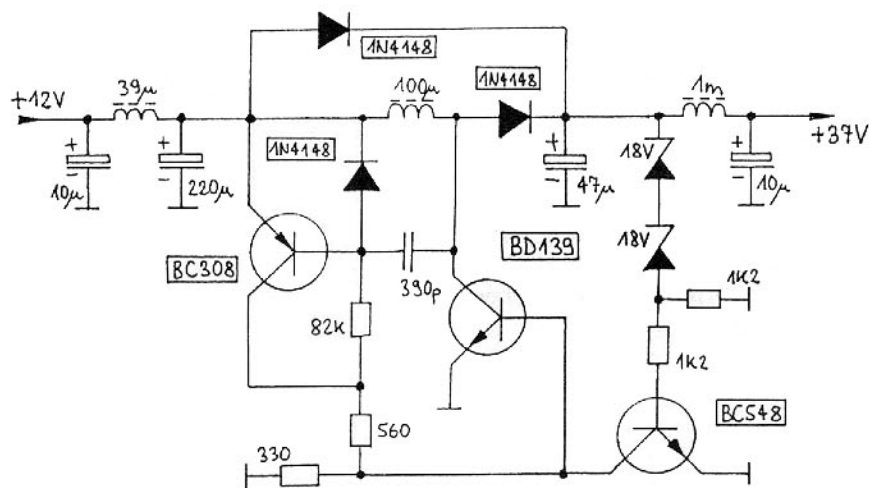


Figure 13. DC/DC converter.

noise level of the described detector is around -105dBm, while the logarithmic response is acceptable up to -10dBm, resulting in a dynamic range of at least 95dB. Another advantage of the described circuit is that the output does not saturate but becomes linear for an additional increase of the input signal level of 10...15dB beyond the nominal logarithmic response. The latter is very useful to clearly indicate excessive signal levels on a spectrum-analyzer display.

A drawback of the described circuit is a rather low output voltage, only around 100mV difference for a dynamic range of almost 100dB. The output video signal is therefore

related to a reference voltage provided by a dummy BF199 amplifier, operated at the same current as the remaining twenty BF199s used in real amplifier stages. Without this compensation the output voltage would change by 2mV (meaning 2dB!) for each degree of temperature change.

The described logarithmic detector requires a video amplifier to boost the output signal level. A suitable circuit is shown in Figure 10. The overall voltage gain amounts to about 50 and is distributed among three operational amplifiers to improve the video bandwidth. The fourth operational amplifier of the MC33074 boosts the reference. The

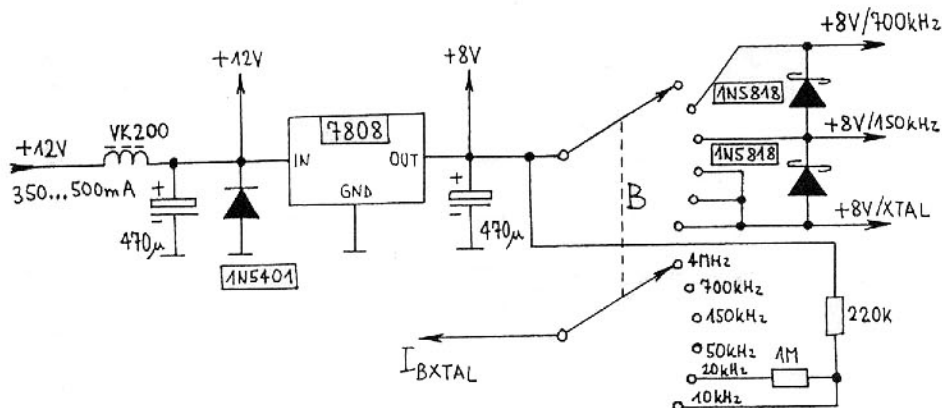


Figure 14. Power supply.

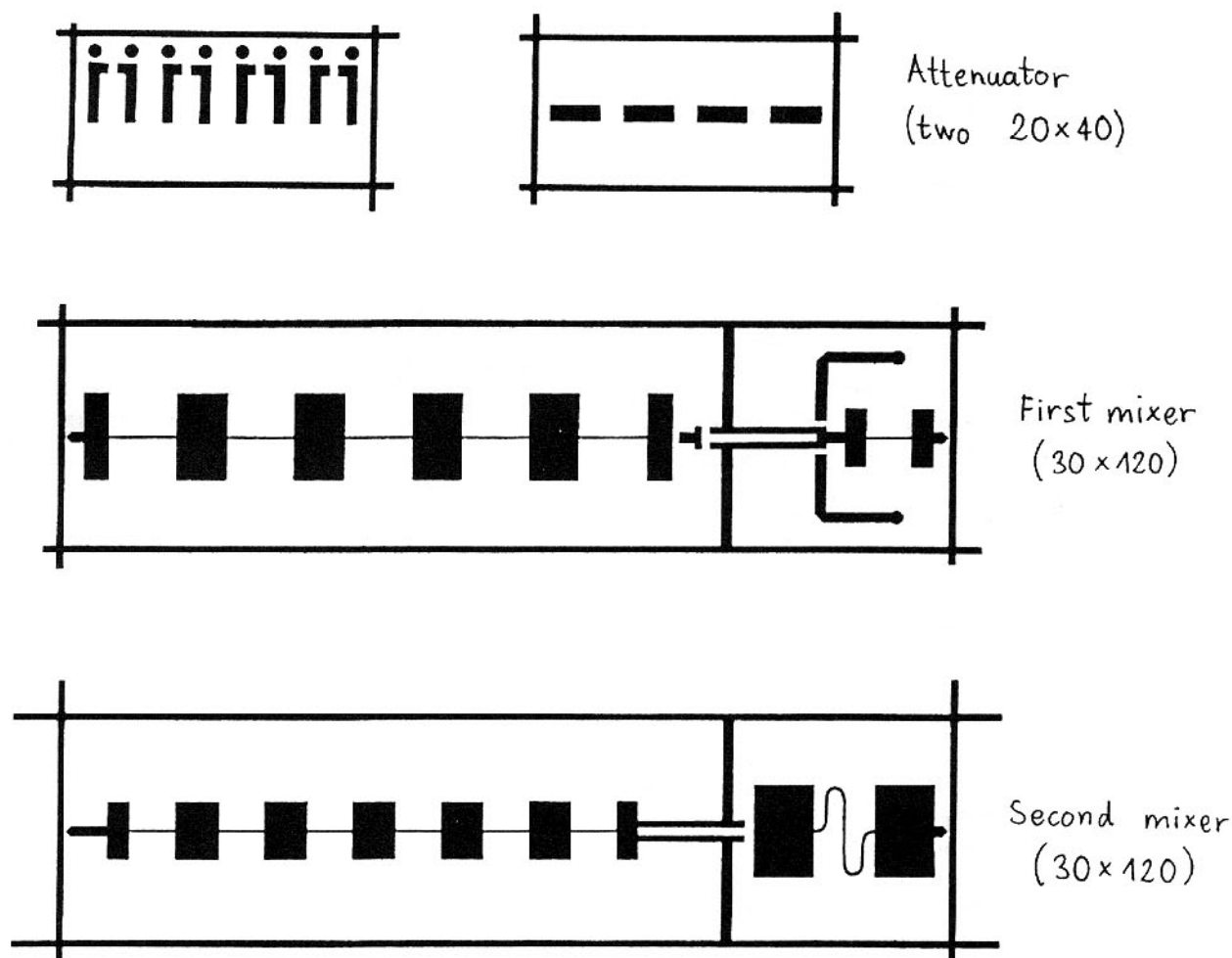


Figure 15. Microstrip circuit boards.

MC33074 includes four relatively fast operational amplifiers (unity-gain bandwidth 4MHz), so that the bandwidth of the overall video amplifier is about 500kHz.

The video amplifier includes two trimmers to adjust the offset (DC component) and gain. The gain should be set for an output of 20dB/V. The output circuit includes a simple video lowpass filter to limit the video bandwidth to 20kHz or 1kHz. An additional audio output is provided to drive earphones with the emitter follower BD139. The video amplifier module also includes a uA723 regulator to supply the logarithmic detector.

Sawtooth Generator and Linearization

Almost any oscilloscope can be used as a display for the described spectrum analyzer. Although most oscilloscopes have a built-in sawtooth generator for the horizontal deflection, the generated sawtooth is usually an internal signal inside the oscilloscope and is not made available externally. A spectrum

analyzer should therefore include its own sawtooth generator to drive the oscilloscope in the XY mode or synchronize the internal sawtooth generator in the oscilloscope.

The spectrum-analyzer sawtooth generator is shown in Figure 11. The shortest sweep time is set to about 20ms or in other words corresponding to a 2ms/div sweep on the oscilloscope. The sweep time can be increased up to 20 times with the 220klog potentiometer. On the other hand, sweep times shorter than 20ms usually make no sense in a RF spectrum analyzer.

The sawtooth generator is built with a quad operational amplifier MC33074. The MC33074 performs different functions: constant-current source, sawtooth oscillator and two output amplifiers. The circuit provides two sawtooth signals for the VCO sweep and display sweep as well as trigger pulses. The supply voltage is stabilized to 30V with the integrated regulator uA723 and BD139 power transistor.

The sawtooth signal may sweep the first VCO (wide scans), the second VCO (narrow scans) or none of them in the zero-span mode. The sawtooth amplitude defines the span width. Besides the span width also the center frequencies of both VCOs have to be set to the desired values.

The described functions require several switches, selectors and potentiometers on the front panel of the spectrum analyzer. Their wiring is shown on Figure 12 together with the linearization circuit for the wideband VCO. The center frequencies of both VCOs are set with 10-turn Helipot. The span width is set with a selector in steps 1/2/5/10 etc. At 500kHz/div and narrower spans the second VCO is swept, while the frequency of the first VCO can be additionally stabilized with the STAB VCO#1 switch. Finally, the zero-span function is activated by yet another switch that removes the sawtooth and connects 47uF capacitors in parallel with the control inputs of both VCOs. (End of Part 1)

6Z6 Award Available

Ramon Santoyo, XE1KK reports on amsat-bb that the Federacion Mexicana de Radio Experimentadores (FMRE) announced that the 6Z6 award (six stations from each six Mexican zones) can be issued with a satellite endorsement. Also mentioned was a 6Z6 Plus award if one of the contacts was made with XF4. The contacts must be made after 01 January 1979 with six zone/six stations (XE1, XE2, XE3, XF1, XF2, XF3 and XF4). The six QSLs and a list of the QSOs should be mailed to FMRE, A.C. Comision de Diplomas Apartado Postal 907, C.P. 06000, Mexico, D. F. Mexico with US\$3.00 money order for return postage. Note that photocopies of the QSLs can substitute for original QSL cards if they are signed by your country's IARU society. For more information: www.fmre.org.mx and/or mailto: fmre@supernet.com.mx.

Ramon notes that for this award, stations can be easily worked from the US and Canada since many XEs are regular operators of UO-10, AO-27, and RS-13. Also several XF4 expeditions were active on satellite (XF4CI was active in all of them!). However, this award may be a little bit harder for the rest of the world but not impossible.

Alaska Inside Passage with K0LEE

Lee Devlin, K0LEE of Greeley, Colorado thanks all the stations that made his Alaskan Inside Passage Cruise a *satellite grid square success*. K0LEE activated 15 grid squares from the ship with new grids worked from: CN89, CO70, CO52, CO53, CO34, CO28, CO29, CO19, CO18, CO26, CO45, CO44, CO43, CO60, and CN79. K0LEE made more than 120 contacts and received a lot of interest from the bystanders while working satellites from the deck of the cruise ship. He also realized that AK stations have a tremendous advantage on the polar-orbiting FM birds and routinely carry on rag chews on these birds with frequent long passes each day. The mayhem subsides substantially after the satellite's footprint clears the U.S.

Stations worked by K0LEE included K6CCC, K6YK, K7XQ, KB0VBZ, KC7QFS, N7SFI, KK5DO, KK5YY, KC0COU, KI0AG, N0VSE, KL0BK, KL0RM, KL4E, NL7E, KW7E, KO6TH, N2YQP, N7QBZ, N7WNX, VE5SWL, VE6EGN, W6QJ, W7JPI, W7VEW, WA4III, W5BTS, WB6JTJ, WB7AEA, WB7SFO, WL7BD, WL7VO, XE2CK, and XE2YVW. See

<http://members.aol.com/lee810/ham.html> for more information on K0LEE's cruise.

Letter for Transponder Modes on Phase 3D Updated

A while ago it was decided to use a two letter designator Phase 3D instead of the old single letter transponder mode designators, simply because there are so many different combinations of receivers and transmitters possible. The first letter stands for the uplink, the second letter for the downlink.

Letter	Frequency	Remarks
T	21 MHz	Uplink only
H	24 MHz	Uplink only
V	145 MHz	Uplink and Downlink
U	435 MHz	Uplink and Downlink
L	1.2 GHz	Two Uplinks only, L1 and L2
S	2.4 GHz	Two Uplinks and two Downlinks, S1 and S2
C	5.6 GHz	Uplink only
X	10 GHz	Downlink only
K	24 GHz	Downlink only

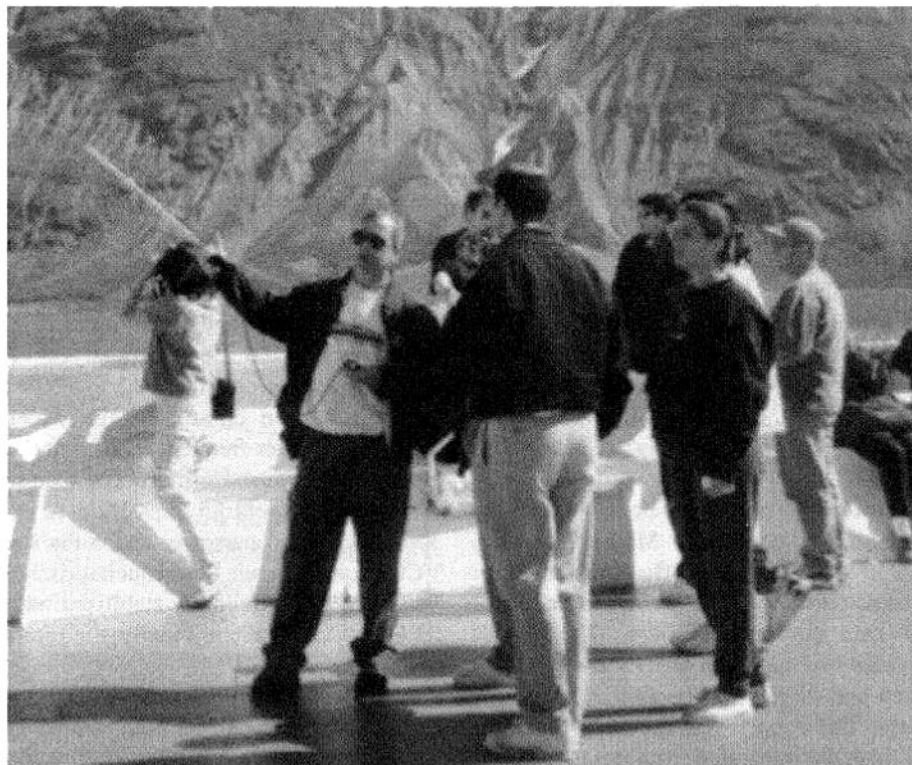
These letter assignments are consistent with the usual microwave band designations, where "K" for example means 18-26.5 GHz. Unfortunately the HF bands do not have such fancy letters, so we let Matjaz Vidmar, S53MV decide, since he built the 21 and 24 MHz receivers for Phase 3D. He commented that the Russian satellites used "T" for their 21 MHz transponder and suggested to use the same letter again. There was however no letter for the 24 MHz RX and we finally decided to use the letter "H".

73s Peter, DB2OS; Freddy, ON6UG; and Matjaz, S53MV

Fire Destroys W0CA's Shack

On 26 May 2000 a fire that was caused by lightning destroyed the satellite shack of Nick Laub, W0CA located in Waynesville, North Carolina. The cause of the fire as determined by Investigative Resource Global, Inc. was a clamp fastened to the 8-foot ground rod used to ground the 80-foot tower. Over time, the clamp developed a stress fracture and split away from the ground rod. The one inch copper braid that was used to ground all the electronic equipment in the ham shack was fastened to the tower, and since the tower was not grounded it afforded an excellent path for lightning to enter the building. W0CA's moral is even if you don't think it necessary to inspect strange things like your grounding straps - do it anyway!

As the photos show, after the fire, there was absolutely nothing left to salvage! As a result W0CA's satellite station is a thing of the past. 10,000 QSL cards went flying through the air after high capacity capacitors



Lee Devlin, K0LEE draws a crowd during a satellite pass during an Alaska passage.

exploded and from the pressure of the fire hoses. Logs from 1929 to the present are now ashes. The loving cup awarded to W0CA for garnering almost 4,000,000 points in AMSAT/STONER Grid Square Challenge is a crumpled piece of metal.

A small overview of W0CA's accomplishments during his satellite operations from Black Duck, Minnesota and Waynesville, North Carolina are:

- First satellite QSO on OSCAR 3, 15 March 1965 with Don Schultz, W0PAM.
- First ever to work WAC on the low earth orbiting birds. This was something that IARU and ARRL said couldn't be done so there was no award immediately available!
- Took first place in the AMSAT/STONER Grid Square Challenge Cup with 3,945,000 points.
- One of the few hams on the low earth orbiting satellites to work 100 countries and 50 states.

With the launch of Phase 3D rapidly approaching, W0CA wonders whether he will soon be up and operating?

Hypersat and Dartsat Satellite Construction News

By Bill Burden, W1BRE

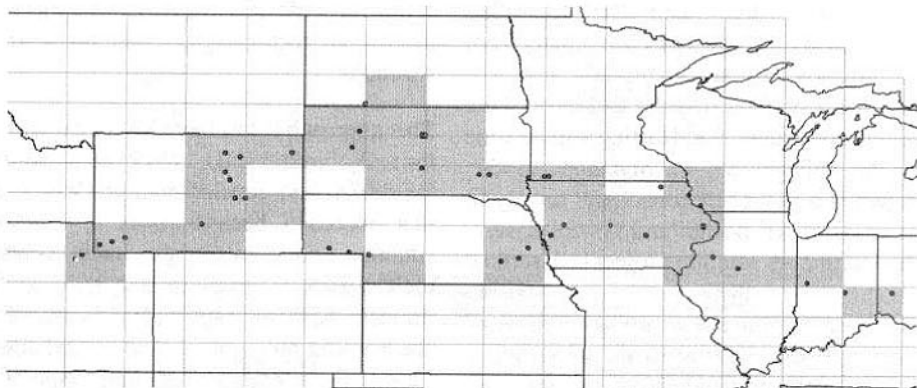
Here is a summary of the satellite design efforts I currently find myself involved in. This is work-in-process and we may see some changes as opportunities change and technology advances. I started out with just the idea of using a local team of Hams from my local club for doing a little design and build effort for a Stensat-type unit. Events conspired to expand the effort into the Thayer School of Engineering at Dartmouth College and I have found myself increasingly challenged by the project.

As a result, I now find myself involved in two projects here. We have a volunteer team of club hams and consultants working on a picosat design. Called *Hypersat*, this satellite will be similar to the Stensat design that was launched earlier this year. That unit was deployed successfully, but never came on the air. Much of what we are doing is building on the experience of the first Stensat effort.

I got going on this with a prod from Bob Twiggs, KE6QMD of Stanford University



Before and after photographs of W0CA's shack. Note what is left of the ICOM IC-761 with the remains of microphone, left as it was put down after last contact with friend in Australia.



Randy Kohlwey, N7SFI reports he made 227 QSO's from 79 callsigns in the 4118 miles he traveled during his DX grid expedition while enroute from his home in Park City, UT to the Dayton Hamvention in Ohio. Eleven states and 35 grid squares were activated on satellite while to and from the Dayton 2000 Hamvention.

and we are working on a basic design module consisting of a 4" by 3" by 1" aluminum frame. The original STENSAT design provided for batteries, transmitter and receiver and control circuitry on two PCBs resulting in a complete 2m/70cm repeater. We are looking at modular stacking on this basic frame to allow more room for batteries and electronics. The basic design is set and will include either NiCd or NiMH batteries and solar panels as well as the old reliable *tape measure* antennas.

We don't have a launch date for our *Hypersat* yet, but I'm optimistic that a small package like this will find a ride on some commercial launch vehicle. Who knows, this satellite is small enough for an astronaut to *toss* into orbit from ISS or *Mir*!

We initiated this volunteer satellite project through our local club, Twin State Radio Club. They are sponsoring the effort and I have drawn heavily on club members for technical, manufacturing and test support. We have already received excellent support from a local company, HyperTherm on fabricating an aluminum chassis. Their manufacturing VP is Mark Buck N9ELC, a TSRC club member. His engineering team used the chassis design to train on a new software design package and produced 4 *production chassis* for us for just the cost of material!

Earlier this year, I was asked to present the project to the engineering school at Dartmouth College for consideration as a graduate project. One of the graduate students, Todd Kerner KB2BCT, is a club member and arranged for me to *sell* the idea to a group of interested students and some staff members. The staff at Dartmouth reviewed and approved the project and now a team of seven engineering students are working closely with Bob Twiggs, KE6QMD on the design of a satellite which is 10cm on a side. Their satellite, called *Dartsat*, may include a physics project from the Physics lab at Dartmouth and will include a 2m/70cm repeater and most of the design, construction and testing will be done by the college. My involvement in this project is a volunteer consultant, mostly in the areas of RF design and system design. The Dartmouth satellite project is described on their website: <http://engineering.dartmouth.edu/~dartsat/> Presently, the *Dartsat* team now has a launch opportunity in 2001, so they are working hard to complete the satellite by the end of 2000.

In both designs, the small size drives us to use cellular telephone technology wherever possible to take advantage of low voltage and low power circuits.

With this sort of project, I believe we are moving amateur satellite design and construction back to its roots as a *cottage industry*. Our volunteer project with TSRC is somewhat unique with a medium sized local club actively involved in the design and construction of a satellite system. Incidentally, this is the first time I have attempted to do project management via Internet and the web and it is working out pretty well so far, although it does present some interesting challenges. For my satellite project, I am consulting with a materials engineer in Florida and we have team members in eastern Vermont and across the river in NH, so keeping the team in contact via the web is very important.

One final note, the cost of these satellites is small; the 10cm *Dartsat* should cost a few thousand dollars to fabricate. I am hoping my own *Hypersat* will be less than \$2,000, not including material and labor donations. We will be scrounging environmental test opportunities from supportive companies in the local area as the projects progress. Fortunately, we have been building a network of contacts with local companies via club members and should be able to do most of the testing required.

By bringing the design and construction of small amateur satellites back to the *local* level, we can more directly involve hams in development of this resource. I can also see the possibility of developing an *inventory* of completed picosats, designed for low earth orbit applications and providing FM repeater capability. These birds could allow us to respond to short term launch opportunities with an *off-the-shelf* capability. In addition, a modular design could provide for the incorporation of innovative technologies even on a short schedule.

This approach is just one idea for expanding the role of individual hams or small teams in the design and development process. I like this approach because it is a *hands-on* situation and it encourages hams to bring their particular areas of expertise to the project. Also, as I am finding, some of us are learning much more than we expected! I am back to the books on many aspects of this effort and I find the prospect of learning both challenging and exciting!

Announcing Microwave Update 2000

Microwave Update 2000 will be held 29-30 September 2000 at the Holiday Inn Select, Bucks County just north of Philadelphia, PA. This year, Microwave Update will be hosted by the Mt. Airy VHF Radio Club, Inc. a.k.a *The Pack Rats*. The Holiday Inn Select, Bucks County will be providing accommodations for the event.

Anyone wishing to present and/or submit papers on equipment design, construction, or propagation at frequencies above 900 MHz for inclusion in the printed copy of the proceedings should contact John Sortor, Conference Chairman at JohnKB3XG@aol.com. The deadline for papers is Monday, 07 August 2000.

For those of you that are unaware, the *Pack Rats* are a group of VHF and Above enthusiast's with a 44 year history. The club was started by a small group from Philadelphia with the sole purpose of promoting VHF activity. The club has sponsored one of the area's best hamfests (Hamarama) for the past 28 years and has hosted the Mid-Atlantic States VHF Conference since 1975. The Pack Rats provide beacons on 10 VHF/Microwave bands from 50 MHz through 10 GHz and are active in all VHF contests.

Room rates will be in the low to mid \$80's. There is no additional charge for double occupancy. We have blocked out 100 rooms under the key code "Microwave Update" which will be held for us until September 7th. This might sound like a lot of rooms but don't wait until the last minute to make your reservation via: Holiday Inn Select, Bucks County, 4700 Street Road, Trevese, PA 19053, Telephone: 215-364-2000, www.basshotels.com/holiday-inn.

Of course it wouldn't be Microwave Update without the surplus tour. There are more new and surplus houses within a 50-mile radius around the Holiday Inn than you will be able to visit in one day. I said new equipment because Down East Microwave Factory Tours will be on the list. There will be evening flea markets at the hotel and don't forget Hamarama on Sunday. Please add flashlights to your packing list. The doors to the Pack Rats hamfest (Hamarama) open Sunday at 8 am but Hamarama has always been known for the *Flashlight Shoppers*. Also, noise figure testing will be provided as well as an equipment tune-up clinic.

Advance Registration is \$40.00 with forms available at the web site below. Send registration to Microwave Update, PO Box 682, Hatboro, PA 19040. Hamarama and Dinner tickets will be available at the door. For more information contact JohnKB3XG@aol.com and visit the Pack Rats web page for the latest news on Microwave Update 2000 at http://www.ij.net/packrats/MUD_2000/mud.html.

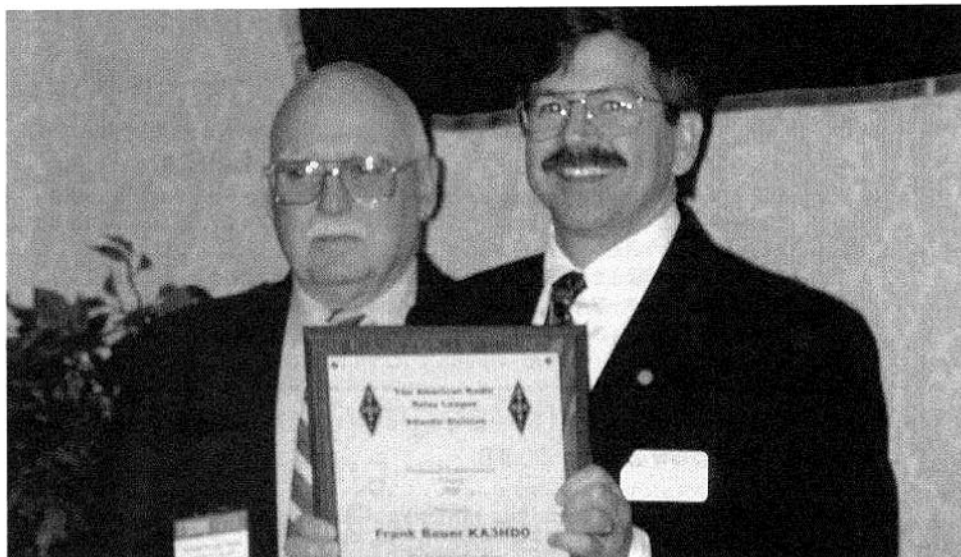
Frank Bauer, KA3HDO Receives ARRL Technical Achievement Award

Rick Lindquist, N1RL, ARRL Senior News Editor, has announced that the ARRL Technical Achievement Award 2000 has been awarded to Frank Bauer, KA3HDO.

Living in Silver Spring, Maryland with his wife Janet and their three children, Frank is a graduate of Purdue University, earning BS and MS degrees in Aeronautical and Astronautical Engineering. An active ham, KA3HDO has served as Vice President of the Goddard Amateur Radio Club for the past two years. He is active in Club programs including education and outreach, Field Day, AMSAT, and the ARRL.

In his AMSAT-NA role, KA3HDO is currently Vice President for Human Space Flight Programs. He was actively involved in Phase 3D, responsible for the spaceborne GPS flight experiment and for vibration testing of the satellite. Frank is also a member of the SAREX Working Group and was responsible for the acquisition, integration and testing of the ARISS Initial Station VHF and UHF radio, TNC, cables and antenna sets for the International Space Station. This equipment will be flown later this year on the Space Shuttle and installed in the Russian FGB Module. In addition, Frank was responsible for setting up and operating the world-wide retransmission of Space Shuttle Air-to-Ground Communications from the Goddard Amateur Radio Club station, WA3NAN — from its initiation in 1983 until 1990.

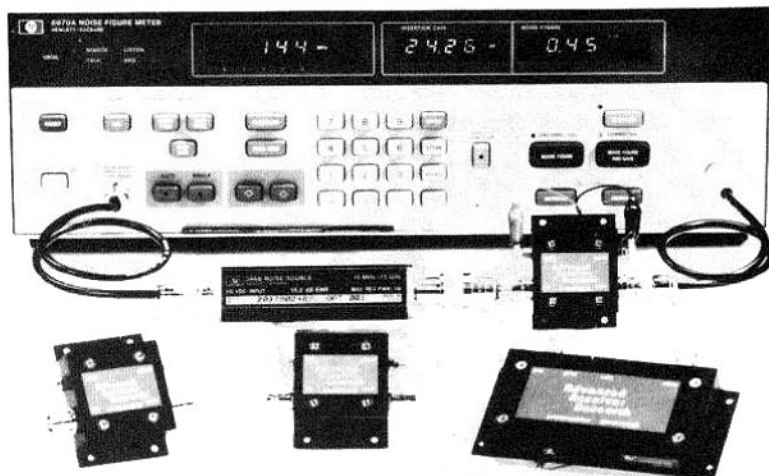
In his professional career, Frank is Chief of the Guidance, Navigation and Control Center (GNCC) at NASA's Goddard Space Flight Center.



The Technical Excellence award was presented to KA3HDO at the June ARRL Annual Atlantic Division Banquet in Rochester, New York.

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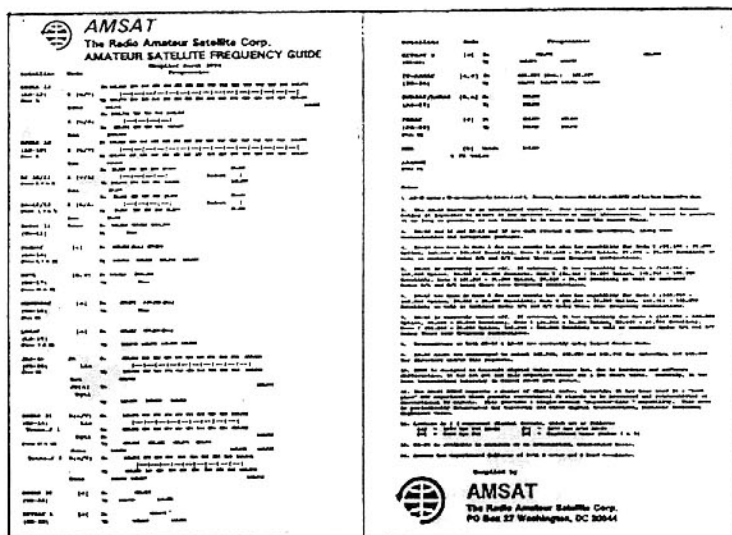
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